JUNE 1958

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Burrows in St. Peter pay St. Paul: sandstone utility tunnels facilitate maintenance

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Coming Meetings

AWWA SECTIONS

Jun. 25–27—Pennsylvania Section, at Hotel Lawrence, Erie. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Sep. 8–10—Michigan Section, at Pantlind Hotel, Grand Rapids. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, DeWitt Rd., Lansing 4.

Sep. 10–12—New York Section, at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Rm. 1525, 19 W. 50th St., New York 20, N.Y.

Sep. 15–17—Rocky Mountain Section, at Cosmopolitan Hotel, Denver, Colo. Secretary, V. A. Vaseen, Ripple & Howe, 426 Cooper Bldg., Denver, Colo.

Sep. 17–19—Ohio Section, at Statlet Hotel, Cleveland. Secretary, J. H. Bass, Robert F. McGivern & Assocs., 1771—5th Ave., Columbus.

Sep. 17–19—Wisconsin Section, at Hotel Wausau, Wausau. Secretary, Harry Breimeister, Chief Utilities Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 22–24—Kentucky-Tennessee Section, at Peabody Hotel, Memphis, Tenn. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–26—North Central Section, at Hotel Duluth, Duluth, Minn. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

Sep. 28–30—Missouri Section, at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, State Office Bldg., Jefferson City.

Sep. 28–Oct. 1—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Mgr., Greenwood Utilities, Box 866, Greenwood, Miss.

Oct. 1–3—Canadian Section, Maritime Branch, at Lord Beaverbrook Hotel, Fredericton, N.B. Secretary, J. D. Kline, Asst. Mgr. & Chief Engr., 162 Lady Hammond Rd., Halifax, N.S.

Oct. 15–17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19–22—Florida Section, at Golden Gate Hotel, North Miami Beach. Secretary, John G. Simmons, Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach.

(*Continued on page 8*)

Coming Meetings

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Oct. 23–24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23–25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29–31—Chesapeake Section, at Hotel Dupont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington 15, D.C.

Nov. 5–7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

OTHER ORGANIZATIONS

Jun. 16–18—Hydraulics Conference, Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City, Iowa.

Jun. 22–27—American Society for Testing Materials, Hotel Statler, Boston, Mass.

Jun. 23–27—American Society of Civil Engineers Summer National Convention, Hotel Multnomah, Portland, Ore. For information, write: Attendance Promotion Committee, ASCE National Convention, Box 508, Portland 7, Ore.

Sep. 1–13—2nd International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

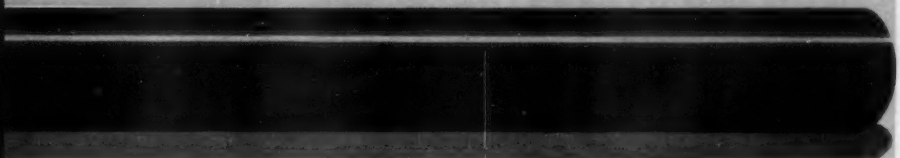
Sep. 7–11—World Power Conference, Canadian Sectional Meeting, Queen Elizabeth Hotel, Montreal, Que. Write: Canadian National Committee of the World Power Conference, Rm. 500, 150 Wellington St., Ottawa 4, Ont.

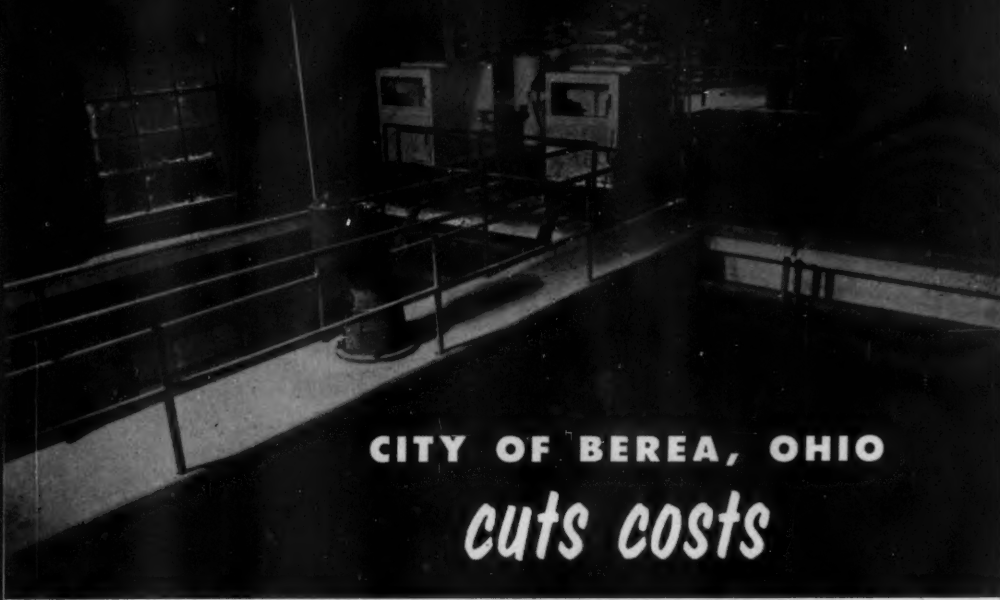
Sep. 15–20—International Congress on Large Dams, Statler Hotel, New York, N.Y. For information, write: US Committee on Large Dams, c/o Engineers Joint Council, 29 W. 39th St., New York 18, N.Y.

Oct. 5–8—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, Hotel Statler, Boston, Mass. For information, write: Albert H. Hall, Exec. Vice-Pres., NIGP, 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 5–9—Federation of Sewage & Industrial Wastes Assns., Detroit, Mich.

Oct. 13–17—American Society of Civil Engineers, New York, N.Y.





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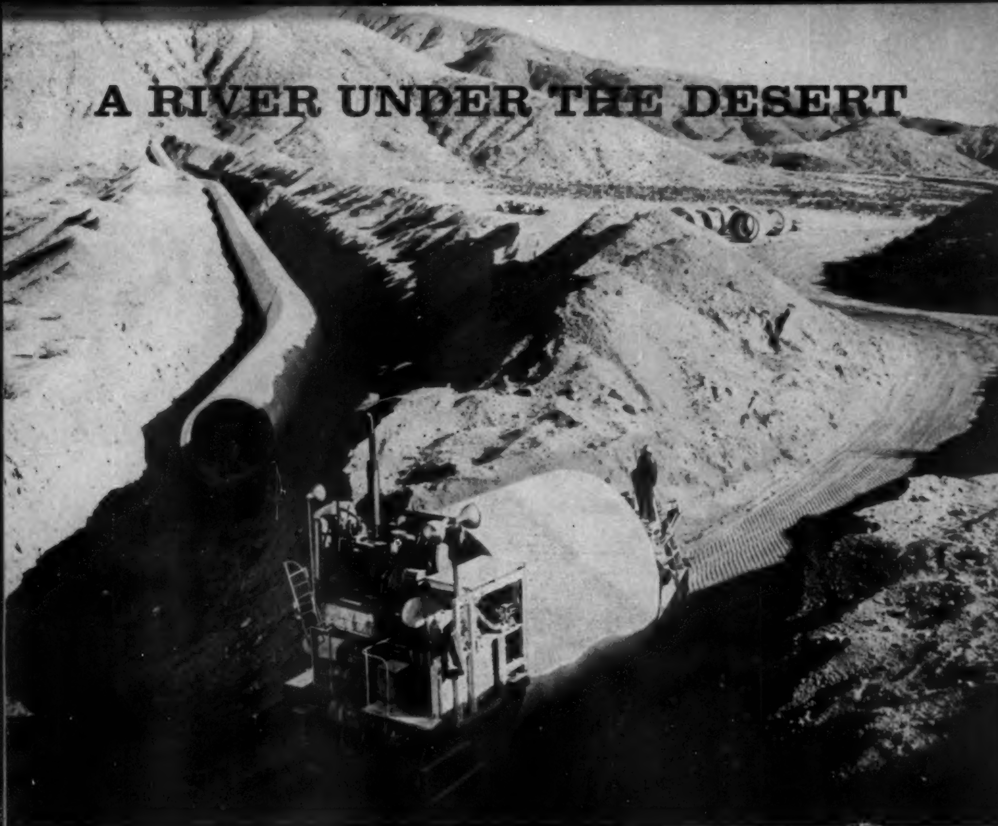

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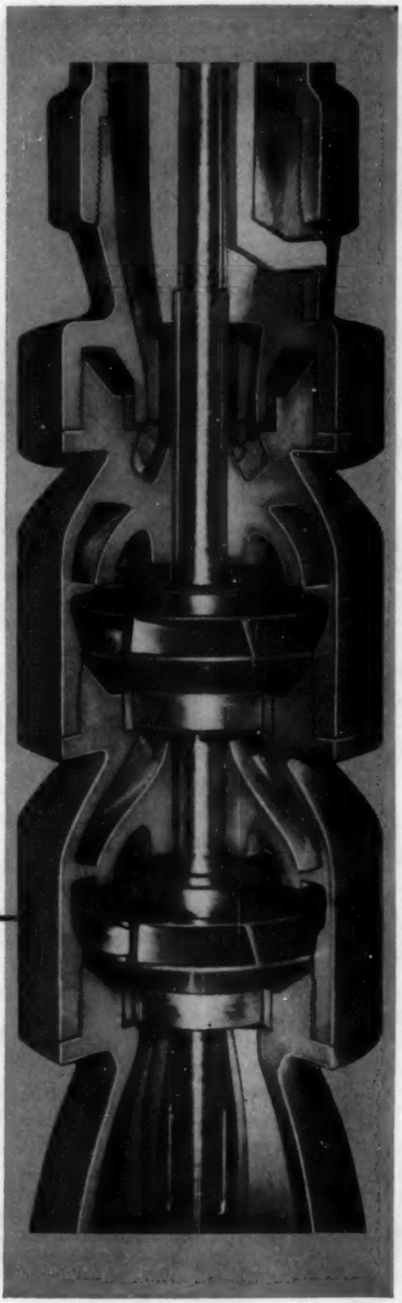

Journal
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Financing Water Utilities in 1958

Carl H. Chatters

A paper presented on Mar. 27, 1958, at the Illinois Section Meeting, Chicago, Ill., by Carl H. Chatters, City Comptroller, Chicago, Ill.

CAPITAL improvements for water utilities will be more costly in 1958 than ever before, but those who must borrow money for construction and improvements will find money available at lower interest rates. The amount of new borrowing for water utilities is expected to continue to increase, until the water debt issued in 1967 reaches a total of about $2,100,000,000, compared with $700,000,000 in 1957. At present (March 1958), those who can sell bonds maturing within 10 years will receive unusually low interest rates.

Competent projections (*1*) have been made of new bond offerings by state and local governments. They are shown in Table 1. About 70 per cent of the water and sewer bonds are for water purposes only.

Construction Financing

The backlog of proposed water utility construction by all levels of government amounted to $2,425,000,000 in January 1958. This was an increase of 7.8 per cent as compared with January 1957. This backlog has increased steadily from $576,000,000 as of Dec. 31, 1944 (*2, 3*). Of the total $2,400,000,000 in public water utility construction backlog as of the end of 1957 for the country as a whole, $131,800,000 was to be spent in Illinois (*3*).

The outlook for 1958 is for an increase in water utility activities. The *Engineering News-Record* forecasts an increase of 15 per cent in contract awards for public water utilities in 1958 as compared with 1957 (*3*). The year 1957 saw a 4 per cent increase over 1956.* These figures, it should be noted, are for contract awards for all levels of government, federal, state, and local. They are not directly comparable to the US Census Bureau statistics on municipal expenditures used elsewhere. Since most government

* Dollar amounts were: 1956, $356,000,000; 1957, $369,000,000; 1958 forecast, $425,000,000.

TABLE 1

Projected New Bond Offerings of State and Local Governments

Year	Total	Water and Sewers
	billion dollars	
1957	6.2	1.0
1958	7.2	1.3
1959	7.9	1.5
1960	8.6	1.7
1961	9.4	1.9
1962	10.4	2.1
1963	11.4	2.3
1964	12.2	2.5
1965	13.0	2.7
1966	14.2	2.9
1967	15.4	3.1

expenditures for water utilities are made by local units, however, the rate of increase forecast for the year appears properly applicable to municipal water utilities.

Financing a water system is a two-sided proposition and includes cost of construction and cost of money. Since 1945, the former has climbed steadily upward so that the construction cost index for 1957 was 135 per cent higher than in 1945. The long-term interest rates for high-grade municipal bonds, while they increased by 116 per cent over the same period (see Table 2), were down during 1954 and 1955 and then resumed their upward course in 1956 and 1957. During 1958 to date, the construction cost index continued moving up while bond interest rates have been dropping considerably.

Cost Index

If any single index were to be used as indicative of the trend of water utility construction costs, the construction cost index of the *Engineering News-Record* would serve the purpose adequately. This index shows an increase in construction costs from an annual average of 236 in 1939 to 724 in 1957 (1913 equals 100). It seems that this upward trend will continue in 1958 because the index is reported to have increased further from 738 in December 1957 to 744.27 for the week of Mar. 6, 1958.

A more precise cost index for an individual water plant consists of a series of seven component indexes. By using individual components for the seven major classes of water utility plant investment, a special cost index can be developed, matched to the pecu-

TABLE 2

Long-Term Borrowing and Construction Cost Indexes

Year	Bond Yield† *per cent*	ENR Construction Cost Index (1913 = 100)
1930	4.07	203
1932	4.65	157
1934	4.03	198
1935	3.40	196
1936	3.07	206
1938	2.91	236
1939	2.76	236
1941	2.10	258
1942	2.36	276
1943	2.06	290
1945	1.67	308
1946	1.64	346
1947	2.01	413
1948	2.40	461
1949	2.21	477
1950	1.98	510
1952	2.19	569
1953	2.72	600
1954	2.34	628
1956	2.93	692
1957	3.60	724
Jan. 1957	—	708
Dec. 1957	—	738
Jan. 1958	3.32	—

* Data from Ref. 4 and *Bond Outlook* (Standard & Poor).
† Average high-grade municipal bonds.

liar characteristics of any individual water property. Table 3 lists these components and their indexes of increased costs from 1946 to 1956 (*4*). These cost indexes have an important bearing on choosing between pay-as-you-go and borrowing policies by water utility managers.

Overall Financial Picture

A utility management should observe the overall financial picture for city-operated water supply systems, as reported by the US Bureau of the Census. Its figures show that 1956 revenues from city-operated water utilities were $1,002,093,000, while expenditures amounted to $1,182,230,000 (current operation, $534,192,000; capital outlay, $546,964,000; interest payments, $101,074,000).

Outstanding long-term debt of these water systems in 1956 totaled $3,579,454,000; $1,998,835,000 was for full-faith-and-credit bonds, and $1,580,619,000 for nonguaranteed debts, primarily revenue bonds. The relatively large proportion of revenue bonds is significant. New long-term bonds issued during the year amounted to $403,239,000; $152,041,000 of debt was redeemed.

A preliminary estimate by the US Census Bureau for 1957 indicates a sizable increase in long-term municipal debt for all types of utilities. If water utilities show the same proportionate debt increase in 1957 as estimated for all types of utilities, then the long-term debt of city-operated water utilities will amount to a total of $4,900,000,000 at the end of 1957.

Illinois Practice

Illinois cities make wide use of water revenue bonds and certificates. The basic statutory authority in the state of Illinois pertaining to the acquisition and financing of water systems by local governments is contained in Chap. 24, 42, and 111 2/3 of the Illinois revised statutes.

Chapter 24, the Revised Cities and Villages Act, provides, in part, for: construction and acquisition of water utilities by cities, villages, and municipalities; and borrowing money and issuing bonds for that purpose.

Chapter 42, which contains the Illinois Drainage Code, provides, among other things, for: acquisition of properties by drainage, sanitary, and other districts; and financing district operations. These districts are empowered to levy taxes, to issue bonds, and to pledge their revenues in payment of debt incurred.

TABLE 3

Index of Increased Utility Costs

Component	1946	1956
	1913 = 100	
Reservoirs	346.0	692.4
Buildings	298.7	548.7
Pumps and motors	173.8	371.0
Distribution systems	360.2	735.9
Services	329.9	701.0
Meters	222.5	460.9
Other equipment	185.1	303.1

Chapter 111 2/3 provides for: acquisition of water utility properties by public water districts, water service districts, and water authorities; and financing such operations through borrowed funds.

At the present time 175 cities in Illinois have revenue bonds or certificates outstanding for the financing of water utilities. Thirty-eight other cities have combination bonds outstanding; that is, bonds for water utilities and some other

purposes, usually sewers. Water utility financing in Illinois is carried on predominantly by revenue bonds and revenue certificates. The proportion of revenue bond financing is much greater in Illinois than in the United States as a whole.

Suggestions for 1958

1. Plan improvements and borrowing sufficiently in advance so as not to be rushed into hasty and ill-advised decisions and financial arrangements. This is very important.

2. Neither in 1958 nor in any other year will a utility management gain by delaying new construction and major betterments. The history of construction costs, except as they may be affected by an acute depression, shows that the costs of inflation exceed the cost of borrowed money. Such a trend seems bound to continue. A water plant costing $346,000 in 1946 would have increased in cost to $724,000 by 1957, according to the ENR Index.

3. An interest should be taken in promoting federal legislation to permit local banks to underwrite or trade in water bonds and certificates. They cannot now do so.

4. A water utility should issue the shortest-term bonds consistent with ability to pay. The market now wants bonds that mature very shortly. In some cases the utility may be able to speed up construction which it intended to pay for from earnings by borrowing for 10 years, or even less. In early 1947 long-term and short-term bonds bore about the same interest rates. Now (early 1958), short-term bonds pay about one-half the interest of long-term securities.

5. When water bonds have an established market, it is best as a general rule to sell at public sale and award on the basis of sealed bids. There are justified exceptions to this rule, however. Illinois statutes do not require public sale and competitive bidding.

6. Never combine the cost of financing with other costs, such as engineering, in a "package deal" in such a way that both the interest rate and the dollar cost of engineering services are hidden.

7. Use callable bonds with caution. They are highly desirable under some circumstances, and costly and confusing at other times. Issue them only if there is a reasonable certainty of calling the bonds. The bonds should be callable no sooner than 10 years after issue. Provide for calling bonds by tender as well as by lot. Bonds must be callable at a premium which declines as they approach their stated maturities.

8. Short-term (under 10 years) interest rates have already decreased greatly in 1958. Long-term rates are more likely to decline than to rise, but their direction is contingent primarily on federal policies with respect to long-term debt.

9. The timing and planning of a bond sale may influence the interest rate. If possible, try to sell when the market is not glutted with new issues. As a rule, avoid selling on Fridays or the day before a holiday. The dealers who purchase these bonds wish to sell them before the week end and want time to check their bids on the day they place the bids with the utility. Be ready to award the bonds immediately after bids are opened, even though a special council meeting may be required to make the award.

10. Be careful what part of sovereignty the utility surrenders in any special financing arrangements.

11. Better interest rates can be obtained if accounting and operational procedures are in good shape, if good reports are available, and if the job of selling bond issues recognizes the needs and wishes of underwriters and investors.

Summary

The outlook for water utility financing in 1958 indicates a larger volume of construction at higher unit prices than in 1956 or 1957, together with somewhat lower long-term interest rates and greatly reduced short-term rates. There should be no shortages of labor, materials, or money. Only inadequate planning need delay any desirable construction in 1958.

Acknowledgment

The author acknowledges the extensive help rendered by Maurice Criz of his staff in preparing this paper.

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2. Construction Scoreboard. *Eng. News-Record,* **160**:9:89 (1958).
3. The Construction Market: Review of '57 and ENR's Forecast for 1958. *Eng. News-Record,* **160**:7:49 (1958).
4. ENR's Annual Report on Construction Costs. *Eng. News-Record,* **159**:15:95 (1957).

Utility Tunnels Beneath St. Paul, Minn.

Leonard N. Thompson

A contribution to the Journal by Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul, Minn.

THE white man's acquisition of the future site of St. Paul is reminiscent of another historic deal with the Indian natives, the purchase of Manhattan Island. It was in 1805 that President Jefferson sent an emissary to the Indian inhabitants of the Minnesota Territory with an offer of 60 gal of whisky and a quantity of pretty trinkets as the proposed and accepted price for the present site of St. Paul and certain additional areas. It should be added that Congress, in a spirit of fairness, voted later to present the former owners with $2,000. The city was first called "Innijiska" by the Indians, which meant "White Rock." Later, the 2,000 white inhabitants built a church and dedicated it to the saint, Paul, from whom the city gained its name.

The city is picturesquely located on a series of terraces overlooking the Mississippi River from either bank. The 55-sq mi area consists of three main levels: the bottom lands just above the river; the middle level, which includes the principal business and wholesale area; and the plateau, or high level, consisting principally of the residential areas, which rise from 100 ft to as high as 340 ft above the river.

St. Paul's water system dates back to 1865. By that time, the small town had reached the point where it could no longer get along with wells, cisterns, and springs. In 1882, the city purchased the private company, and expansion of both the sources of supply and the distribution system started in earnest.

Much of the St. Paul area is underlain by a St. Peter sandstone and Shakopee limestone, from which is obtainable a fine supply of water. Industries, large office buildings, and hotels obtain an average of about 20 mgd from this source. The city supply, however, has always been from nearby lakes and the Mississippi River.

Early Construction

The proximity of the sandstone to the surface, particularly in the original downtown area, created a problem for the original installers of the water distribution system. Modern types of equipment were, of course, not available in those days, and open cuts were slow. Labor was both plentiful and cheap, however, so many utility installations were made in tunnels cut through the sandstone. It is estimated that today there are approximately 70 mi of these tunnels, constructed at various times by the water department, sewer department, telephone company, and power company. The tunnels of the different utilities often parallel and cross each other at different depths and with independent entrances.

The tunnels used by the water department were mostly installed in the early years, or between 1870 and 1895, although new drifts and short extensions are occasionally required today. Water utility tunnels follow the same course as the streets above and generally are about 20 ft below the street surface. Excavations were made entirely by hand, and the pick marks are still plainly visible. The excavated materials were moved from the headings by small wheelbarrows and hauled to the surface by buckets and hand winches. The tunnels are approximately 6 ft in height and generally approximately 3½ ft wide (Fig. 1). The water mains are laid along one side. Services are carried from the main through a drift from the main tunnel to a point near the front of the property to be served. A small drill hole between this drift and the basement of the consumer is provided for continuation of the water services. The water meters are placed in the tunnel at the end of the drift, or immediately at or near the drill hole.

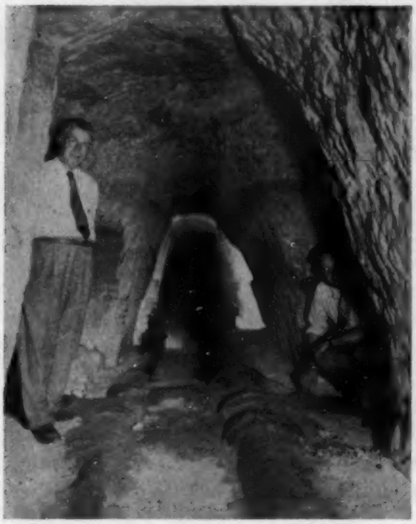

Fig. 1. View of Utility Tunnel

Mains laid as shown above are easily accessible for maintenance. Tunnel dimensions are approximately 6 × 3½ ft.

Hydrant connections are made in the usual manner, with the hydrant lead or branch laid in the drift to a point under the curb where the line is carried up through a deep manhole reaching to the street level above.

A review of some of the early contracts let for the construction of the tunnels is interesting. The average contract costs were 75–80 cents per foot of tunnel and drill hole and $60 per hydrant shaft hole. The cost of the hydrants was about $48.

Present Use

Maintenance and any extensions are now done by day labor. The sandstone is rather soft and easily cut, but it has held its shape very well over the years. Lanterns and candles were originally used by the men who had occasion to enter the tunnels, and many a man who failed to carry a well filled lantern, candles, and matches has experienced a few bad hours trying to find his way in complete darkness back to an entrance. Today, the underground streets are all identified at the intersections to correspond to the streets above, and, of course, electric lights and flashlights have helped. The author knows from experience that groping along a dark tunnel for several hours with little or no sense of direction does not come under the heading of a pleasant afternoon stroll.

The water department has been very fortunate in the very few leaks that have occurred in these tunnels. One break in a 6-in. line several years ago, however, which flooded the tunnel for some distance, showed the need for methods by which the water could be carried away fast enough to permit entrance so that control valves could be closed. This was accomplished by a connection between the floor of the tunnel and a large sewer tunnel at a lower level.

Streams of vehicular and pedestrian traffic pass along the streets above, but very few people realize that the hydrant on the corner is fed from water mains laid in a small street 20 ft below.

Governmental Units in Metropolitan Areas

Information from the US Bureau of the Census reveals that more than 15,000 local governments operate in the 174 metropolitan areas that include and surround cities of 50,000 or more population.

According to an article which appeared in the *News Letter* of the Municipal Finance Officers Association (Vol. 33, No. 3, Feb. 1, 1958), about three-fifths of the nation's population resides within these areas, which are served by more than one-seventh of its local governments.

Most of the nation's increase in population since 1950 has occurred in metropolitan areas, chiefly in the suburban portions surrounding the central cities. With this suburban growth have come problems of making provision for water and sanitary services, as well as schools, police and fire protection, and other community needs.

Since 1952, 170 new municipalities and 519 new special district governments have come into being in metropolitan areas. During the same 5 years, on the other hand, the number of school districts in metropolitan areas decreased by some 1,600 as a result of consolidations and reorganizations.

The number of each of the major types of local governments within metropolitan areas in 1957 and 1952, and related US totals as of 1957, are as follows:

Type of Government	Number in Metropolitan Areas 1957	Number in Metropolitan Areas 1952	1957 Total Number in US
Counties	266	267	3,047
Municipalities	3,422	3,252	17,183
Townships and New England towns	2,317	2,344	17,198
Special districts	3,180	2,661	14,405
School districts	6,473	8,106	50,446
Total	15,658	16,630	102,279

Development of Management Skills: Necessity or Fad?

Richard H. McCleery

A paper presented on Jan. 17, 1958, at the Inservice Training Course for Water Works Supervisors (cosponsored by the Michigan Section, AWWA), at Michigan State Univ., East Lansing, Mich., by Richard H. McCleery, Prof., Dept. of Political Science, College of Business & Public Service, Michigan State Univ., East Lansing, Mich.

THE development of management skills is a subject which has given rise to recent fads and fashions in the field of administration. The importance of skilled management goes without saying, and the necessity for achieving this skill has stimulated varied approaches in progressive government and industry. This article will evaluate those approaches and suggest a point of view which may have value for the municipal utility.

The first problem seems to be an identification of management skills. There are a number of conventional responses normally made to the question of what management is—"capacity to delegate authority" or the "clear assignment of responsibility," among others. Such responses tell very little and, as directions to the manager, they are about as useful as an instruction to "pass the buck." In order to avoid the appearance of clarity on a subject which is, in truth, rich in confusion, this article will start with the most general definition of management skills and then discuss ways by which a concrete examination of the matter can proceed. A simple list of skills will include:

1. The full utilization of human and material resources
2. Careful anticipation of future needs and developments
3. Coordination and the resolution of conflict within and without the agency.

The third item—a subject of disproportionate emphasis in the field—is little more than the ability to get out of the difficulties that bad management has created. It is the eraser on the pencil of management.

Survey of Literature

One of the several methods to be noted later for the development of management skills is an awareness of ideas in the relevant publications. As a stranger to the details of utility management, the author has used the approach of looking into the trade publications for items relevant to this discussion. On the evidence found there, it seems that the problems of management and administration have not been a serious concern of the water utility profession.

A survey of the literature shows, first, a tremendous concentration on the utilization of material resources

and almost nothing on the utilization of human resources. A person able to understand the technical language involved could learn in detail the ability of pipes and machines to withstand stress and perform under various conditions, but he would find next to nothing on abilities of men to stand stress or perform under various conditions. Both the literature and some survey of practices indicate that a trained talent for getting the most from physical resources has not been applied to the human material. There are water utilities which are satisfied with one-third of the time, 10 per cent of the intelligence, and none of the initiative of their employees, but they are concerned about 20 per cent leakage of the product.

Second, there is a concern for anticipating future needs by projections from the past on the basis of internal records of the agency. There is little mention of knowing or shaping the future by means of active participation of water utility management in the policy decisions of the community which shape future demands. There is little concern with guiding and directing an informed public opinion on vital community interests (fluoridation, annexation, or civil defense) affected by water resources.

Finally, there is a constant emphasis on avoiding conflict by means of withdrawal from politics. Although there is some evidence of concern with the solution of internal and external problems after they appear, there is less discussion of the positive managerial skills which prevent the appearance of these problems. There is no indication that water management has assumed the positive role of community membership and responsibility which has marked progressive private enterprise in recent times.

In summary, the literature shows little concern with identification and development of management skills as these skills are defined herein.

The lack of attention to management skills and problems can be excused on the ground that the answers are not complete. The study of management cannot produce a set of answers as a guide book to performance. It goes little beyond the identification of the problem and some of the vital questions which may be asked about the problem. The author's purpose is to get people to ask the right questions in their own situation and to seek the answers which apply. The first rule is that the answers vary from place to place, in one situation or another, depending on factors such as the extent of unionization or the ratio of professional to common labor in an agency. The question of how to enlist the full resources of talent, energy, and imagination in an agency remains standard.

It may be useful to trace some of the approaches to the study of management skills which have been employed in the past. These approaches may be classified as biographical, legal, and sociological. Something can be learned from their failures as well as their accomplishments.

Biographical Approach

The biographical approach involves the study of the lives of great organization men. It assumes that the scholar can seek a number of especially well run agencies and identify management skills in the qualities of the successful executive. The answers to good administration are to be found as characteristics of the good administrator:

1. A good administrator establishes and sticks by standard procedures, but he is never caught in red tape.

2. He is always available to his employees, but never bypasses the responsible chain of command.

3. He delegates authority and responsibility, but always stands behind subordinates, accepts blame for failures, and backs the agency.

4. He is warm, friendly, and personal, but he never lets personality influence his action.

5. He makes decisions quickly and firmly, but never makes snap judgments or fails to weigh all sides of a matter.

6. He budgets his own time, orders his affairs carefully, keeps a clean desk, and avoids submersion in trivia, but he is flexible, adaptable, and familiar with all the details of the organization.

7. He is a good father, a loving husband, and an active member of his community, but he lets nothing come before his responsibility to his organization.

There are two possible interpretations of this mass of data. Either the good manager is a dangerously split personality and terribly confused, or the efficiency of the organization has little connection with the personal characteristics of the manager. The second conclusion is hard to accept. People like to think of their agency as an extension of their own will and personality. People confuse legal responsibility with causation and assume that all that happens in their jurisdiction happens because they want it to, until something goes wrong. Nothing could be farther from the truth. Nothing could be worse management. The best management is that least dependent on a given individual and most able to continue in his absence.

The failure of the biographical approach lies in the fact that the good agency makes the good manager and can make a good manager out of quite different materials. Good management may function because of a good manager or in spite of him.

The clear conclusion is that management skill is a function of the organization as a whole—that the entire set of talents in an agency must combine to utilize resources, anticipate needs, or resolve conflicts. When these skills are thought of as personality quirks of managers, administrators are asking the wrong questions and looking in the wrong place for answers.

Legal Approach

An alternative to the biographical approach to management skill is to look at administration as a set of rules and regulations, sometimes called principles of administration. One school of thought and some schools of administration suggest that the memorization of these rules constitutes the necessary equipment of the manager. To illustrate briefly what these principles and this approach involve, the rules include:

1. Clear assignment of responsibilities
2. Delegation of authority consistent with responsibility
3. Establishment and observance of a chain of command
4. Observance of a supervisory span of control.
5. Fixing determinate lines of communication.

As the first list attempted a description of the characteristics of the good manager, this list describes a good organization. It describes an organization in which each man knows what he is to do, from whom he receives instructions, and to whom he is to report. The ability to describe a good organi-

zation, although it is one useful ability of the manager, is not the same as an ability to create or to direct such an organization.

It has been noted that issuing commands or writing instructions does not insure communication. Communication is a cooperative, interpersonal relationship depending as much on reception of the message as on its origination. The same is true of authority and responsibility. These are not commodities to be transferred in an agency as though they were desk blotters or inkwells. The actual delegation of authority does not take place until it is accepted by the individual and recognized by all of his nominal subordinates. The principle of delegation does not establish what is to be delegated or the conditions under which such a transfer can take place. Many a manager has made the mistake of assigning a responsibility elsewhere only to discover that his own superiors held him to account for resulting failures. The paradox of management is that authority and responsibility can be delegated only where the person receiving them already has authority (by function, status, or experience) and is responsible.

The principles of management, or the memorization of them, are not the same as management skills. The principles describe, in part, an organization in which management skills can and do operate. The development of management skills involves processes which must occur within and throughout the agency.

Sociological Approach

The position advanced in this article is one contrary to some thought and many fads in the management development field. It holds that management skills are not personal qualities on the same order as artistic talents, grey hair, or brown eyes. Skilled management is an organizational characteristic. There are organizations which handle management skillfully, just as there are organizations which build fine cars or deliver good water, but the skilled management is as much an organization product as the car or the water.

Skilled management is full utilization of resources, anticipation of the future, and, when necessary, the solution of unexpected problems. It is more than any individual can supply by himself, although, in a badly managed situation, individual trouble shooters may be busy patching up and painting over past mistakes. Skilled management is possible in a situation where all members of a system feel a pride of identification in common purposes, understand their role in a total process, and feel that the fullest contribution of their talents is a welcome addition to the total product.

There is no combination of talents or individual skills which can solve management problems in an atmosphere of hostility between boss and worker, conflict for private advantage, or confusion as to basic goals. Just as people cannot understand management skills by looking at the qualities of an individual executive, those skills cannot be developed by anything done to the executive or anything taught him after he becomes an executive. There is no profit in management development as a fad.

The major point of this article is that a management development program—the development of management skills—must be a program which approaches the agency as a whole. It must be a program which provides incentive and assistance for employees

through the entire career ladder of the agency, not one which calms the manager's feelings of insecurity after he reaches an executive position with mere formulas. More than this, the program must reward cooperation, promote foresight, and encourage initiative at every agency level. These qualities distributed throughout the agency are the essence of management skills. Given such attitudes within the agency, the manager will be able, in his declining years, to enjoy the luxury of idleness and a clean desk to which past efforts have entitled him. The mark of good management is the extent to which its tasks enlist the fullest measure of energy and initiative present in the organization.

Executive Development

Those who accept the point of view advanced here are prepared to criticize some of the fashions in executive development. At the same time, the details of a management development program are obvious and need little more than illustration. Minimum steps are as follows:

It is necessary, first of all, to recruit young men with the initiative to develop and the intelligence to understand the vital role which water plays in a modern community. That means the recruitment of such men to the lowest ranks of the agency, and it may involve providing pay and working conditions attractive to men of promise. The prospect of joining an organization which rewards talent and encourages development, however, is as much of an attraction as the pay rate to a man with management potential. An aggressive employee seldom fights management when he has some reasonable hope of rising to join its ranks. When the prospects of advancement are slim and the type of man employed is one with no capacity for development, his natural inclination is to oppose a ruling elite which he can never join. The wisest general rule is never to bring into the organization a man who cannot, with full development of his potential, be given a share in its management.

Secondly, an orientation program must give each employee a clear understanding of the importance, the aims, the future, and his own prospects within the organization. This is a continuous process and involves giving the widest view of the organization, its range of activities, and their meaning for the community. Whether it be recognized or not, the vast bulk of the "public relations" of the water utility occur in the relations of its most numerous group of employees with the community and the impression of the utility which they circulate in normal contacts. If each meter reader or ditch digger knows the significance of water in the total life of the community, then the community as a whole will come to know this. If the orientation of a new man is limited to showing him where the men's room is, he can be expected to be found there when he is needed.

In addition, the career ladder of promotion should be clearly established for each employee. When possible, it must be pointed out that the road to advancement may lead outside the agency as well as within it. Training for a given position must include preparation for the next position in the ladder, or training will always be too late. Given this atmosphere, the danger of having good men leave the agency for some other is more than offset by the ability to attract and encourage other good men who see

the agency as an avenue to self-improvement.

Men at every level of the agency must be involved in certain management functions of planning and budgeting agency resources. The laying out of work programs and the budget should be delegated to the lowest levels of the agency for initiation. By decentralizing these management functions to the work crew level, the desire of employees to participate in management, express initiative, and be more than a small cog in the machine is satisfied. The false assumption that management is a function monopolized by an elite class is at the root of many management problems, not the least of which is the demand by organized labor to share in management functions without loyalty to or understanding of the ultimate welfare of the organization. Only by delegating a part of the planning, budget, and public relations process to the work crew level does the executive have an opportunity to identify men with a wide perspective and sense of the future early in their careers.

Finally, at each level of supervision, it is wise to schedule periodic meetings or staff conferences of employees to work on specific problems assigned by top management. Assignments may include such items as personnel turnover, training needs, or equipment utilization. Men marked for promotion in the future should be invited to take part in these joint projects to prepare them for advancement or to test their ability to function at the next level. It may be well to note that an agency does not get good management without setting aside some time for it any more than it gets any other organizational product by wishing for it.

The program steps identified so far are similar in that they give employees a sense of involvement with management, its problems, and its functions. They involve the energy and talent of all the human resources in the problems of management. They provide top management with a chance to identify the talent which can be developed in later stages. More than that, many of the ideas generated at lower levels will be good ideas, and most of them will be realistic. If men are made to believe that their ideas will be respected, they will develop the habit of thought. Finally, when top management adopts ideas generated from below, it will find that projects will be executed by employees with a spirit which never attends the carrying out of projects generated by the front office alone.

Outside Resources

The development of management skills can go on through the second level of supervision with the resources of the agency alone, plus the use of professional literature made available to employees by agency subscription. From that point on, the managerial functions of the employee can best be improved through resources drawn from outside the agency.

The farther a man goes up the management ladder, the more his working environment becomes the community as a whole rather than the agency itself. Concentration on that one aspect of management which is the repairing of past mistakes may obscure that point. But the manager whose environment of action is limited to his own agency is as incompetent as the mechanic who starts his machine without knowing if the other members of

his work crew are clear of it. Any policy decision on water resources management starts a machine which vitally affects every member of a community. To ignore those vital relationships makes a man an irresponsible worker, manager, or citizen. Skilled management is one which functions in terms of the total set of resources and conditions of the environment. This point of view conditions the completion of the steps in management development.

Means must be provided to enable men developed from lower ranks to remove limitations or academic deficiencies. Some men of capacity are handicapped by limitations in accounting, English, or social science from rising in the organization. Corrective work is normally available through continuing education or evening high school classes. Where live classes are not available, a wide range of correspondence courses may serve as well. Management can establish an atmosphere of encouraging self development and initiative by paying for the tuition of such courses when they have been completed.

Professional association meetings and travel to visit outstanding utilities should be available to men who show promise of managerial ability. The opportunity to attend and to broaden a man's horizon should be used as an incentive to develop an interest in management problems. The professional community of the manager becomes that of other managers and administrators as well as his fellow employees. Membership should be encouraged in such groups as the personnel management profession or the American Society for Public Administration.

Finally, a means must be found to involve the managerial group in the civic life of the community. This may take the form of an active leadership by water utility personnel in the problems of civil defense, to which their utility is so directly related. Any activity, however, which identifies the water utility, through its personnel, as a responsible and participating member of the community will serve as well. The immediate and concrete results of a management development program which sends employees into community service lie in the fact that a large part of higher management time is spent in dealing with the public and acting in concert with other agencies. The long-range results are found in the fact that water resource management becomes directly related to the future health and development of the community and is so recognized by the community when decisions are made. Many of the problems of false economy and fragmented development of water services are prevented in this approach.

Conclusions

Skilled management means the projecting of personnel and managerial needs into the future just as physical needs are projected. It means the utilization and development of imagination, intelligence, initiative, loyalty, and experience, just as physical resources are developed. An attempt to concentrate management functions in the hands of a small executive elite only wastes a large proportion of the human resources available to meet the problems of management. Any attempt to manage the functions of providing water apart from the vital interests of the community, which are

directly related to that basic resource, are certain to provoke public resentment. The failure of those who have special knowledge of water resource problems to share that knowledge with their community and guide policy toward a healthy future can only result in the greater problems brought on by public ignorance and apathy. These are a few of the basic conditions which determine the character of a management development program.

Given a recognition of those basic conditions, the detailed job of management development depends on the resources immediately available for the task. Some large corporations send their executives away to a university for a year and finance their study of such subjects as business, philosophy, or art. It probably makes little difference what these men study as long as they are paid to stay away from the business. During their absence, other men are learning to do their jobs and to share in their responsibilities. At the same time, the executive is forgetting much of what he knows about the organization and gaining an awareness of the world as it goes on outside the agency's doors. Both of these developments can only work for the best. At a minimum, an agency can abolish its rule of firing anyone caught reading on company time. In between those extremes, any move which encourages the involvement of thought and energy in the task of planning for the future will avoid many of the problems current now.

Proper Methods for Purchasing Materials

Ray W. Jones

A paper presented on Oct. 31, 1957, at the California Section Meeting, San Jose, Calif., by Ray W. Jones, Supt., Div. of Water & Sewers, Sacramento, Calif.

THERE are certain difficulties involved in discussing the purchasing of materials, because it is a controversial subject, and also, because experience of small water utilities in specifying materials is limited as compared to that of some of the larger utilities. It is not the purpose of this article to make specific recommendations on the purchase of water utility materials, but, rather, to outline what the author believes is the proper procedure on methods to secure full value for money spent.

For the purpose of this article, material is defined as including commodities, equipment, and machinery used in water utility operations.

One of the most important and often vexing problems faced by the water utility administrator, is the selection and the securing of the proper materials. Often, large sums of money are involved in these purchases, making keenly apparent to the conscientious administrator his responsibility to get the public its money's worth. How is this goal achieved?

The basic principle in the purchase of materials is to purchase those which will satisfy all conditions of performance and be the most economical to use. Sound water utility practice dictates that materials which are the lowest in cost * and which satisfy the basic requirements of the application, such as strength, wearing ability, and other desired qualities, are the ones that should be used. To achieve this objective, a thorough investigation should be made of all factors involved. Both economy and performance should be considered so that a proper selection can be made.

Performance

The first criterion to be considered in the selection of a material is performance. In this consideration, past experience plays the most important role. With the advent of World War II and the many technical advances since, however, the specifying of materials only through prior usage can no longer be tolerated if the public is to get its money's worth. For example, the metals industry has developed many corrosion resistant alloys, such as the many grades of stainless steel and high nickel alloys, which produce remarkable results. The plastics in-

* Editor's Note: With reference to the phrase "materials which are the lowest in cost," the author states later in the article that the term "lowest in cost" does not mean "lowest in price." He emphasizes that one of the difficulties which a water utility executive faces is that of avoiding the purchase of material which is "lowest in price," but which is actually of inferior quality and

dustry has developed plastics which have certain applications to water utilities at lower cost and improved performance. New types of valves and equipment are now being produced, which more nearly fit performance needs. A few examples of experience at Sacramento with these new materials may be of interest:

In considering the replacement of wash water gate valves at the filtration plant, which were leaking so badly that wash water could not be contained in the tank for more than a few hours, it was decided after a thorough investigation to change to butterfly valves. These valves have recently been developed with rubber seats to provide drip tight closure. Not only were these valves lower in cost, but they proved to be ideal under the required operating conditions of numerous intermittent closures against low heads and large volumes of flow with no leakage.

In the filtered water reservoir, corrugated-asbestos sheets were used to replace gunite baffle walls, which had collapsed as a result of wave action produced by an earthquake. When these walls collapsed, they carried with them the supporting roof columns to which they were tied, causing extensive damage to the wood (timber) roof. In addition to saving on installation, the use of this material provided future protection against earthquake damage by the design of these sheets to give way under severe wave action. After raising the roof to its normal position, sheets of the corrugated asbestos were used for reroofing, to provide a lifetime job at very little additional cost over an asphalt-felt roofing material.

In the replacement of steel alum piping at the coagulant building, which is subject to severe chemical corrosion, plastic pipe was used with gratifying results and at lower installed cost. In this same building, a steel alum-cooking tank with a lead lining was replaced with a steel tank lined with a $\frac{3}{8}$-in. plastic membrane, protected against excessive heat by two layers of acid-resistant brick. This tank, in contrast to the old one, requires no attention and already has served twice the life of the lead-lined tank.

Economy

Assuming that investigation has shown several materials which will meet performance criteria, the next step in the selection of the proper materials is to evaluate relative economy of those being considered. In evaluating economy, there are three factors to consider in arriving at the most economical materials: first cost, maintenance, and life. Here again, experience, either in the form of personal experience or knowledge derived from others, plays the major role in estimat-

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not capable of rendering the service required.

Although there seems to be a tradition in the public purchasing field that the lowest priced item should be obtained unless a mountain of evidence exists against its purchase, the facts are that quite a few materials are offered for sale, particularly certain basic construction materials such as valves and hydrants, which are made of inferior materials, assembled with inferior workmanship, and totally unsuited to render the type of service that it should.

In this connection, the recent promulgation (*Willing Water* No. 50, February 1958) of the recommendations on certification procedure should be noted. If any water utility manager has the slightest doubt concerning the material which is offered him, he should require the manufacturer or the bidder to furnish a sworn affidavit that the material which is to be supplied does in fact comply with AWWA standards.

ing maintenance costs and expected life of the materials. Once these factors are determined and the first cost is known, the selection of the proper materials will probably be obvious.

If the selection is not so obvious, however, and the magnitude of the purchase calls for further refinement in selection, there are exact mathematical methods of comparison which can be used. One way is to compute the annual cost of capital recovery from the known factors of first cost, depreciation, salvage value, life, and interest rates. This is then added to the estimated annual maintenance and operational charges for comparison of the total annual costs of the materials being considered. A detailed explanation of this method will be found in engineering economics textbooks. Examples of where this method might be used are the comparison of a permanent-type concrete roof on a large reservoir versus a wood roof, or use in a distribution system of steel pipe versus cast-iron pipe.

Specifying Materials

When the question of what materials to use is decided, on the basis of performance and economy, the next problem is that of specifying the material. Most water utilities must purchase materials through a bid procedure, in which the award of the bid goes to the lowest bidder—provided he meets the required specifications. Unfortunately, there are manufacturers which take advantage of this procedure and offer what purchasing agents call bidders' merchandise. Unless due caution is exercised in specifying the material, the water utility manager will be forced to buy an inferior product which barely meets his specifications. Often, the material does not lend itself too well to the writing of detailed specifications, and a specific product or its equal is called for on bid procedure. This method should be avoided wherever possible, as most manufacturers will insist that their product is not only the equal of, but better than, the product specified. Under these conditions, an inferior product may be accepted, without contrary proof. There are particular applications, however, where this method is effective. In the past, for example, it has been difficult to specify brass water service fittings in sufficient detail to get the quality of merchandise needed at Sacramento. Often, fittings that looked like rejects or factory seconds were received. To stop this practice, utility officials now include in specifications an "or equal" clause, naming several reputable manufacturers of these service fittings and requiring all bidders to send samples of the merchandise they propose to furnish. They further stipulate that the service fittings furnished by the successful bidder must measure up to the acceptable samples, which are kept for comparison, or be returned at the manufacturer's expense.

Ordinarily, detailed and complete specifications should be written, covering the materials to be ordered. The time spent and the research made in their preparation should be commensurate with the value of the order. Fortunately, there are available standards prepared by qualified organizations which cover a number of water utility materials. Some of these sources of standards are: AWWA, ASA, ASTM, the US Bureau of Standards, and the US Department of Commerce. Wherever applicable, these standards should be used or modified to fit the need. Specifications

prepared by an individual should be clear and concise, to be sure that there is no possibility of misunderstanding or misinterpretation. Poorly written specifications will often be reflected in a higher bid to allow for uncertainties.

One method which has been used successfully to avoid misinterpretation and possible embarrassment is to write tentative specifications for reputable bidders' comments or exceptions. This method would apply to such complex specifications as expensive pumping or electrical control equipment. In the less important purchases, specications should be written which will invite at least three qualified bidders. An example of where this policy has worked to advantage at Sacramento was in the purchase of some trailer-mounted compressors. After checking the specifications of reliable manufacturers, officials specified an 85-cu ft capacity air compressor with a gas engine drive not to exceed 1,200 rpm. On the basis of the specified revolutions per minute, the utility was able to disqualify one bidder who proposed to furnish what would normally be a 60-cu ft capacity air compressor with an excessive rate to meet capacity requirements. Finally, in writing specifications, wherever applicable, a safety clause should be included, requiring material purchased to conform to the state safety code. It may save the cost of expensive correction or modification of equipment to comply with their requirements.

Records

After exercising the proper diligence in investigation and care in writing the specifications, the utility should be able to purchase the materials which it believes are the best buy for its investment, but the task of getting its money's worth does not end at this point. If the purchase is of materials which will be used in construction or maintenance activities, it is important that these items be entered in a perpetual inventory—an inventory which is perpetually kept up to date. This inventory should serve as a control for buying and for keeping stocks at a minimum. Through its application, the quantity of materials to be purchased can be based upon past experience in usage and delivery time.

If the material purchased is a piece of equipment or machinery subject to repair and maintenance, accurate maintenance records should be kept. This system should be complete enough to accomplish the necessary preventive maintenance, to assure full value in performance, and to serve as a historical record of maintenance cost and life, used as a basis for future replacement. For example, it may pay to replace an old pump if power savings and maintenance costs are analyzed and compared to a modern, more efficient pump.

Summary

Obtaining full value for money spent in the purchase of water utility materials requires thorough investigation and thoughtful preparation of specifications by utility officials, keeping in mind the objective of securing materials which will satisfy all conditions of performance and be the most economical. To gain experience for future purchases and avoid excess stocking of materials, accurate and continuing inventories and maintenance records must be kept.

Service Extensions to Fringe Areas

Thomas J. Eaton

A paper presented on Sep. 24, 1957, at the Rocky Mountain Section Meeting, Santa Fe, N.M., by Thomas J. Eaton, Supt., Public Service Co. of New Mexico, Santa Fe, N.M.

WITH an average annual growth in population of 2.5 per cent nationally (in many parts of the Rocky Mountain Section, it is double or triple that rate), water utilities are faced with problems of expansion. The simplest type of expansion arises when a customer enters the office and requests a water service connection to a new home he proposes to build, and the more complex type is when a subdivider brings in a plot showing a group of contiguous sites on which he wishes to construct homes and service buildings suitable to the area.

If the request for new service shows that it is on a street or tract that adjoins a pipeline which has adequate pressure and volume, the problem is solved for the present. The charges for the new connection should be adequate to conform to an overall policy already established. Possible policies are:

1. There is no initial charge, because the rates will cover costs of service and depreciation and there are sufficient capital funds available to make the investment.

2. A nominal charge is made to cover part of the initial capital investment, and the rate will cover costs of service and depreciation. This type of charge prevents unauthorized applications or applications by persons who want water at their lot, but have no intention of building for possibly years to come.

3. A charge is made to cover the complete original cost from the main to and including the meter at the property line.

Basic Concepts

All of these methods or systems of charges for a service line arise from some basic concepts that were laid down by the water utilities at the start of operation, with later modifications (it is hoped) as conditions changed.

A municipal water department usually is brought into being by the demands of a group of citizens protesting failure of wells, or lack of fire protection, or poor service by an existing water utility. The motivating forces determined the initial policy on charges, and it varies widely in purpose. Some may believe that connections at no charge would give encouragement to potential customers and the revenues thus brought in would maintain service thereafter. Another group may have taken over existing utilities which had gone bankrupt due to unexpected high initial costs or high operating costs or failed to be able to render satisfactory service. Historical records in Santa Fe, N.M., for example, reveal the incorporation of about five companies to provide water to its citizens. All faded or were combined

into the present Public Service Co. of New Mexico.

Today, the initial service, or installation, charge should be reviewed to bring it up to date in line with the present cost or to reevaluate the original purposes and modify them in line with the objects and policies of the present group of operators. This presents a major problem to a municipal group, as well as to private operators. A municipal department is technically responsible to its owners, the public, through the council and mayor or through a separate board with either appointive or elected members. The will to change may be forced on the department by a deficit in operating funds or the necessity for expansion. It must overcome the tendency toward preserving its present status and proceed with the change. Selling the change may take time, and the change may face severe opposition to the point where a favorable vote is required to increase indebtedness. Thoroughly complete facts and figures are concrete evidence of the sincere desire on the part of the utility to do a good job. The services of a reputable consultant give added weight to the impartial survey and its ultimate solution. Bearing in mind the fact that the citizens of any community are individuals, it can be foreseen that complete agreement with any plan is improbable, and it can only be hoped that the opposition will be reasonable and permit the utility to show that the overall justifiable benefits outweigh the added costs or temporary inconvenience.

A private utility deals with the same public, plus a franchise from the city or town, plus a board of directors, plus a state rate-making body. The private utility has one advantage, however: that once the board has approved a policy, it is not faced with opposition from within. It does face one added hazard: the state commission—but usually its procedure can be carried out in 60–90 days and a final decision secured.

There is one basic distinction between a group of individual service applications and an equal number of the same type of service applications submitted by a subdivider. The subdivider usually requires mains in addition, which increases the capacity of the system to take care of the quantity required. Such strengthening of the system is usually neglected when the additional service is requested by individual customers over a period of time. A different main extension policy is required for fringe area customers, arising from a situation where the subdivider wants water so that he may either build homes himself or sell lots on which others may build. No longer can the utility claim that the former landowner should have put in mains before selling lots so that the original cost could have been equitably divided by many. Some types of policy must be made known and adhered to.

Fringe Area Policy

The Public Service Co. of New Mexico has adopted the policy of extending mains to fringe areas at the actual cost of the extension required. The applicant deposits in cash an amount equal to the estimated cost of the mains and is refunded a sum equal to $2\frac{1}{2}$ times the annual revenue for each and every service connected to the extension within a period of 5 years. Both parties sign a contract which outlines the legal formalities and defines limits and areas covered by the agreement. One of the simplest statements limits the refunds to a sum not exceed-

ing the total amount deposited. Another statement gives the subdivider credit at the time of making first refunds for any excess of the deposit over the actual cost, or if the reverse is true, the first refunds are credited to extra cost and the balance paid as due.

In these contracts the cost of services from the main to the street side of the property served is not covered. They are controlled by the same base policy as for any individual—a nominal amount of $10 for a ¾-in. or 1-in. service, including the meter and its setting. Actual costs are in excess of $100 per service, including average pavement-cutting costs. Fortunately, most of the streets are narrow and, up to the present time, less than 15 per cent were paved in overall length. Some California utilities reported costs of $171 per service on their generally much wider streets, and where costs had been split $95 to $76, it is now a policy to charge $151 to the customer and $20 to the utility.

On all main extensions, the critical point is the size of the main to be laid. It is clearly seen that if the New Mexico policy of a refund equal to 2½ times the estimated annual revenue is followed and the revenue is $70, the value of the extension can be shown at $175, or about 75 ft of 4-in. main at an average cost of $2.25 per foot installed. If the main size is 6 in., then at $3.25 per foot, the length is slightly more than 50 ft.

Knowing beforehand what the design for a single customer would require and then having to install a main adequate to serve 50–100 customers and provide fire protection flows in an area not yet built will certainly cause customer protests. The utility can sympathize with them, but only because the customer is realizing for the first time why he was able to purchase the lot or tract at such a comparatively low cost.

The large-scale subdivider goes along with a design as long as he can forsee a 100 per cent return of his contract sum. He protests that it costs him to borrow money to put up for the extension (the individual neglects that cost), and the subdivider wants to put up a promissory note (at no interest) or a bond. The company's answer is that it must pay the material and labor costs at once, and it earns no money until there are customers to whom it can render a bill for service received. The subdivider may say that the utility can borrow the money through its facilities at a low rate and, therefore, it should just add the basic mortgage rate it pays to his costs. On the other hand, the utility cannot serve as agents for the bank; the subdivider must borrow his own money where he can and keep his own books. Often, the utility must present facts about the costs of maintaining the water service and repairs, not omitting the fact that it pays taxes on the added valuation during the initial period when revenues are relatively low.

Expansion of Services

Discussion of fringe area service is restricted in this article to the area covered by the limits of the franchised service area established by the municipality or water district. A broader problem is presented by the service extension requests from outside such an area where consideration must be given to the change of basic policy. Why should service be rendered to anyone not participating in all the costs of operation? Should the rates be different due to added lengths of mains, pumps,

and storage facilities required? How much will added taxes, costs of meter reading, and enforcement of water regulations have to do with the rate base? Naturally, these areas contribute much in business and taxes to the community of which they are not directly a part. On the basis of that fact, the utility is often asked to broaden its outlook and become more metropolitan and progressive in outlook.

Most growing communities of a small size are faced with the problem of slowly increasing revenues from tax sources and rapidly increasing demands for new and improved municipal services. The tendency is, therefore, to expand and annex piecemeal the parts known as fringe areas over a period of time, and then to repeat the process. Using the water utility as a club by means of increased rates for that purpose alone is wrong. A cooperative study by a group composed of both parties interested in the water utility extension is greatly to be desired. The program should be developed by them to the point where it is ready for sponsoring to the community and the fringe area in its final form. It must be fair to both and almost surely will contain compromises that have been agreed to by both. It is here that controversy arises from the extremists, but ultimately the moderates should prevail.

Fringe area expansion also brings up the fundamental fact that costs of main extensions and resulting revenues are affected by the density of population. Within municipal limits there are undeveloped areas being held for profit, and it certainly costs less for the water utility and the municipality to develop the tax base. Improving density within present areas promotes efficient operations for both.

Problems of Revenue

Control of population density may be vested in a city planning commission, which allocates land usage by means of zoning. They are usually optimistic and set up large areas for acre lots and hold down the areas for commercial and industrial usage. The water utility will get its higher usage in the latter zones, but unless lawn and gardens are installed on the acre lots, the revenue will be below average per mile of main and will adversely affect income.

One of the most recent revenue analyses made in Michigan shows that in 37 systems serving over 10,000 population, the investment averaged $9 per dollar of annual sales, and in the cities serving a smaller population the average investment was $15 per dollar of sales. In New Mexico the ratio is $6.70 per dollar of sales for the Santa Fe Water Division, which has an investment of $4,000,000 and revenues of $600,000. The revenues include all taxes, which are not included in the municipal ratios stated above.

These ratios indicate that proportionally the capital turnover is very low in relation to other businesses in a community, with the consequence that after paying on outstanding indebtedness and for operating costs, the amount remaining for depreciation or capital improvements is almost nothing in many cities. In a municipality, if a bookkeeping surplus appears, it is generally transferred to the general funds, and no capital surplus is available for additions or expansion. It is then necessary to arrange for the sale of bonds of a type compatible with the state and local regulations governing such financing. The arranging is sometimes costly both in time and money con-

sumed, especially in the present period of high interest rates. Frequently the financial consultants advise that the revenues are inadequate to support the new financing unless the rates are increased.

Some communities have held their rates to the barest minimum when increases were proposed. Today, with increased payroll and material costs for ordinary maintenance and operation alone, their troubles are likely to become matters of public concern.

For what the public receives from water utilities, it pays very little, and this is reflected in the wages and standards of most water utility operations. One example is the service rendered, without adequate compensation, for fire protection. Utilities provide storage, oversized mains, fire hydrants, and extra pumps, because the fire departments and the association of fire insurance underwriters demand it as a service to the community. No mention is made of the extra costs to the water utility to improve the efficiency of the fire department and to allow the fire insurance agencies to hold premiums at the same cost to the policy holders, while reducing their losses per thousand dollars of insurance in force and therefore making an increased profit. In other businesses, improved efficiencies and added customers are reflected in the pay envelope of the employees, but not in many water utilities, as shown by an AWWA survey (*1*).

Reference

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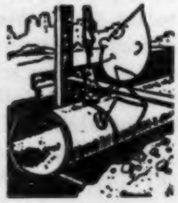

Federal Interagency Activities Concerning Water Supply

Maurice LeBosquet Jr.

A paper presented on Nov. 1, 1957, at the Chesapeake Section Meeting, Washington, D.C., by Maurice LeBosquet Jr., Asst. Chief, Water Supply & Water Pollution Control Program, Div. of San. Eng. Services, USPHS, Washington, D.C.

IN considering federal interagency activities related to water supply, it should be kept in mind that the development of water supplies for domestic, municipal, industrial, and other purposes is generally recognized as a primary responsibility of state and local interests. The federal role is in two fields: [1] seeking new knowledge through research and providing technical assistance, demonstrations, training, and consultation in applying this new knowledge; and [2] basin-wide coordinated planning, interstate problems, and development of specific federal projects. Planning and project development activities stem from the constitutional powers of the federal government and the limitations imposed on any single state by virtue of the interstate character of water resources.

Concerning federal activities related to water supply, an attempt will be made to outline the guiding policies—past, present, and possible future—and to list the authorities and interagency agreements under which these activities are conducted. In this discussion, the words "water supply" will have the usual AWWA meaning of municipal supply, rather than the broader interpretation which includes, in addition, water supply for all other beneficial uses, such as fish and aquatic life, recreational purposes, and agricultural, industrial, and other legitimate purposes.

Authorities

The report of the Presidential Advisory Committee on Water Resources Policy (*1*), transmitted to Congress by the President on Jan. 17, 1956, in outlining designated functions of the federal agencies, included water supply under the Department of the Army (Corps of Engineers) and the Department of the Interior (Bureau of Reclamation). The report recognized municipal and industrial water supply planning, within interagency activities, as functions of the Department of Health, Education, and Welfare (USPHS).

The water supply authority of the Department of the Army stems from the Appropriations Act of 1938 which authorizes the addition of water supply storage in federal projects, provided that users pay for the incremental cost of the added storage. The payment must be made so that it can be expended along with the federal funds during construction. Later, the River and Harbor and Flood Control

Act of 1944 (*2*) authorized the disposal of surplus water for domestic and industrial uses at reasonable prices and terms. Under these authorizations, water from sixteen projects (eight in Texas, four in Ohio, two in North Dakota, and one each in Oklahoma and South Carolina) is supplied to nineteen communities. Storage for water supply totals 1,014,141 acre-ft or 330 bil gal (*3*). A list of individual projects is shown in Table 1.

The Department of the Interior under reclamation law has had, for many years, authority for the sale of water from Bureau of Reclamation projects for purposes other than irrigation, such as municipal water supply, if such sale will not result in detriment to irrigation services. Under this authority, water from 26 projects (six in California, four in Oregon, three each in Colorado and South Dakota, with the balance scattered) is supplied to 165 principal contracting entities which, in turn, supply a population of 1,072,083 with 165,360 acre-ft or 54 bil gal of water per year. This is equivalent to 148 mgd, or 138 gpcd (*4*). A summary of individual projects is shown in Table 2.

TABLE 1

Water Supply Storage Provided in Reservoirs Constructed by Army Corps of Engineers

Project	Water Supply Storage *acre-ft*	Local Agency
San Angelo, Tex.	80,351	Upper Colorado River Authority
Berlin Dam, Ohio	19,400	Mahoning Valley Sanitary Dist.
Mosquito Creek, Ohio	11,000	Warren, Ohio
Burr Oak, Ohio	9,300	state of Ohio
Hords Creek, Tex.	5,780	Coleman, Tex
Garza-Little Elm (Lewisville), Tex.	415,000	Dallas, Tex.
Garza-Little Elm (Lewisville), Tex.	21,000	Denton, Tex.
Grapevine, Tex.	85,000	Dallas, Tex.
Grapevine, Tex.	50,000	Park Cities, Tex.
Grapevine, Tex.	1,250	Grapevine, Tex.
Lavon Dam, Tex.	100,000	North Texas Municipal Water Dist.
Delaware Dam, Ohio	5,700	Columbus, Ohio
Texarkana, Ark.–Tex.	13,400	Texarkana, Ark.–Tex.
Lake Texoma, Okla.–Tex.	21,300	Denison, Tex.
Belton, Tex.	12,300	Fort Hood, Tex.
Canton Dam, Okla.	90,000	Oklahoma City, Okla.
Clark Hill, Ga.–S.C.	210	McCormick, S.C.
Homme Res., N.D.	3,650	Grafton and Park River, N.D.
Baldhill Res., N.D.	69,500	Eastern North Dakota Water Development Association
Total	1,014,141	

The authority of the USPHS stems from the Public Health Service Act of 1912, as amended, and from the Federal Water Pollution Control Act (*5*). Under the Public Health Service Act (*6*), the service conducts research, investigations, and other activities re-

TABLE 2—*Uses of Water From Bureau of Reclamation Projects, 1956* *

Project	State	Municipal Water Service		Industrial Water Service		Other		Total	
		Contracting Entities	Total Water Delivered *acre-ft*	Contracting Entities	Total Water Delivered *acre-ft*	Contracting Entities	Total Water Delivered *acre-ft*	Contracting Entities	Total Water Delivered *acre-ft*
Arnold	Oregon	0	0	1	50	0	0	1	50
Columbia Basin	Washington	4	539	2	4	1	142	7	685
Crescent Lake Dam	Oregon	1	5	0	0	0	0	1	5
Deschutes	Oregon	2	1,461	1	182	0	0	3	1,643
Lewiston Orchards†	Idaho	1	410	0	0	0	0	1	410
Cachuma	California	2	1,731	0	0	0	0	2	1,731
Central Valley	California	1	997	4	800	63	35,523	68	37,320
Klamath	California-Oregon	3	47	0	0	0	0	3	47
Orland	California	0	0	0	0	1	100	1	100
Boulder Canyon	Ariz.-Calif.-Nev.	8	18,000	0	0	0	0	8	18,000
Gila	Arizona	2	1,859	5	35	3	159	10	2,053
Salt River	Arizona	1	42,456	0	0	0	0	1	42,456
Yuma	Arizona-California	0	0	0	0	2	80	2	80
Mancos	Colorado	1	245	0	0	—	120	1	365
Newlands	Nevada	1	1,095	1	3,650	0	0	2	4,745
Pine River Indian Irrigation	Colorado	1	800	0	0	0	0	1	800
Provo River	Utah	5	23,819	3	3,768	17	6,898	25	34,485
W. C. Austin	Oklahoma	1	4,123	0	0	1	8	2	4,131
Rio Grande	New Mexico-Texas	1	988	0	0	0	0	1	988
Belle Fourche	South Dakota	3	254	0	0	1	152	4	406
Huntley	Montana	4	444	0	0	0	0	4	444
Milk River	Montana	2	3,000	0	0	0	0	2	3,000
Missouri River Basin									
Angostura Unit	South Dakota	0	0	2	46	0	0	2	46
Rapid Valley	South Dakota	1	2,688	0	0	0	0	1	2,688
Riverton	Wyoming	1	50	0	0	0	0	1	50
Colorado-Big Thompson	Colorado	9	7,106	2	1,526	0	0	11	8,632
Total		55	112,117	21	10,061	89	43,182	165	165,360

* Projects not furnishing municipal, industrial, or other nonirrigation water are not listed.
† The Lewiston Orchards project contracts with 2,010 consumers, but for purposes of this table, these consumers are included as one contracting entity.

lating to the diseases of man, including water purification and pollution of lakes and streams. Engineering and scientific knowledge useful in the planning, design, and operation of water supplies has been developed under this authority. Also under this law, the USPHS certifies nearly 1,400 interstate carrier water supplies, which furnish water to nearly 75 per cent of the nation's population served by public water supplies. Under the Federal Water Pollution Control Act (*5*), the surgeon general is directed to develop comprehensive programs for eliminating or reducing pollution, giving due regard to the improvements necessary to conserve such waters for public water supplies, propagation of fish and other aquatic and wildlife, recreational purposes, and agricultural, industrial, and other legitimate uses. The act also contains provisions for the collection, in cooperation with other agencies, of basic data on water quality relating to pollution, for enforcement of abatement measures for pollution of an interstate nature, and for financial aid to interstate agencies, states, and municipalities for water pollution programs and for construction of treatment facilities.

The Department of Agriculture, under the River and Harbor and Flood Control Act of 1944 (*2*), has responsibilities for flood prevention in eleven watersheds. Under this authority, three municipalities, plus a number of small rural communities, have contracted for additions to flood prevention structures to furnish municipal water supply. The three municipalities are Duncan, Okla., on the Washita River, Chickasha, Okla., also on the Washita River, and Kaufman, Tex., on Brady Creek, a tributary of Trinity River. More recently, through passage of legislation amending the Watershed Protection and Flood Prevention Act (*7*), the Department of Agriculture has been authorized to support works of improvement for municipal and industrial water supply and other purposes through loans, provided the works of improvement are an integral part of the plan for the protection and improvement of an entire watershed. There has been great interest in this program and one project, which will furnish water from Upper Graves Creek to Cameron, W.Va., is under construction.

The Housing and Home Finance Agency, under housing amendments of 1955 (*8*), can offer assistance for general community facilities, including municipal water supply. Two types of assistance are offered: advances for planning and public facility loans. Planning advances under this program can be for both preliminary and final planning. As construction is started, planning advances are required to be repaid to the federal government. Loans are made only when funds cannot be obtained from other places at reasonable rates, which is interpreted to be an interest rate higher than currently asked by the agency.

Under these various federal authorizations, direct assistance is provided to municipalities in developing public water supplies. A multitude of other authorizations are related to water supply and are indirectly helpful to municipalities in water supply development. These include basic data collection, research, planning, and various defense activities.

Interagency Committees

Interagency coordination in water supply and other resources activities was placed on a formal basis with the

establishment in December 1943 of the Federal Inter-Agency River Basin Committee (FIARBC). The commissioner of reclamation, the chief of engineers of the US Army, the land use coordinator of the Department of Agriculture, and the chairman of the Federal Power Commission were parties to the agreement establishing the committee. The Department of Commerce, Department of Health, Education, and Welfare (then the Federal Security Agency), and Department of Labor became members of the committee during the next 10 years.

The committee was effective in establishing cooperation in the preparation of reports, correlation of planning, notification of investigations, interchange of data, and mutual consultation. Subcommittees on hydrology, sedimentation, and economic analysis, and interagency field committees in the Missouri Basin, Columbia Basin, and Pacific Southwest were established. Interagency river basin committees in the Arkansas-White-Red River basins and the New England-New York area were established in 1950 in response to the President's directive concerning interagency coordination of the surveys authorized in these areas under the 1950 Flood Control Act.

FIARBC was succeeded by the Inter-Agency Committee on Water Resources (ICWR), established through agreement by the heads of the participating federal agencies and approved by the President on May 26, 1954. The five field committees have all been rechartered under the new committee. At all times, the state governors are represented and participate in the work of the field committees. The Department of Health, Education, and Welfare is a member of the various committees and participates, through the USPHS, in interagency activities. USPHS interest stems from the rapidly expanding water requirements for domestic, municipal, and industrial uses, as well as pollution control. Consideration is given to water quality conservation, to limiting factors resulting from adverse water quality, and to health hazards, including control of insects. An indirect result of USPHS participation has been improved representation of state and local health and water pollution control agencies in consideration of the planning of water resource developments.

Project Review

The Bureau of the Budget, in recommending water resource development projects to the President for submission to Congress, has attempted to accomplish a degree of uniformity in project analysis. This has been done through the issuance on Dec. 31, 1952, of circular No. A-47 dealing with "reports and budget estimates relating to federal programs and projects for conservation, development, or use of water and related land resources." This circular contains a number of policy points which are of interest in the development of municipal water supply. Specifically, Sec. 21 of the circular restricts provisions which are made for future nonfederal water requirements, such as excess storage capacity in reservoirs for municipal or industrial water supply, to not more than 15 per cent of the total construction costs. Liberalization of this provision would benefit municipal use. Sec. 21 further provides that initial use of proposed additions to a project, such as for municipal water supply, must begin within 10 years, and the contract must

be signed by local interests, prior to the beginning of construction, agreeing to start payment within such 10-year period. Thus, there has been no ". . . authority for inclusion of storage for water supply where customers were not available to pay for it, even though it may be evident that water supply needs will develop in a reasonable time and that best development of a reservoir site should include storage for water supply . . ." (*9*). In issuing the circular, the Bureau of the Budget pointed out that the circular was not intended to restrict the content of agency reports nor to determine the position which agencies may take with regard to substantive issues.

Special Field Committees

The 1950 Flood Control Act authorized comprehensive surveys of the water and related land resources of the New England-New York area and the Arkansas-White-Red River basins. Special interagency field committees cooperated in these surveys and prepared reports which were submitted to Congress. In these reports, specific effort was made to give consideration to the needs of municipal water supply in the overall planning. In the New England-New York area, water is plentiful and the report for that area indicates that, in general, ample provision for municipal water supply should create no great problem. A summary of this report is being published as Senate Document No. 14, of the 85th Congress.

The situation in the Arkansas-White-Red area was somewhat different, and the matter of municipal water supply played an important part in the preparation of the report (*10*). In commenting on the report, however, the Department of Health, Education, and Welfare pointed out that evaluation of potential water supply sources was limited to study of multipurpose project plans proposed by the principal constructing agencies. Here again, the need for broadening the consideration given to municipal water supply needs is recognized.

Future

Passage of legislation now before Congress would assist water supply development by broadening authority to permit impoundment in Department of the Army and Department of the Interior projects in accordance with the following provisions (*11*):

> . . . it is hereby provided that storage may also be included in any reservoir project surveyed, planned, constructed or to be planned, surveyed and/or constructed by the Corps of Engineers or the Bureau of Reclamation to impound water for present or anticipated future demand or need for municipal or industrial water, and the reasonable value thereof may be taken into account in estimating the economic value of the entire project: Provided: That when the contract for the use of such impounded waters is made it shall be on the basis that will provide equitable reimbursement to the United States as determined by the Secretary of the Army or the Secretary of the Interior. . . .

[This bill was passed by Congress, but, on Apr. 15, 1958, it was vetoed by the President. The veto message cited eight defects in the bill, one of which was described, in part, as follows: ". . . It would also authorize the inclusion of municipal and industrial water supply storage in such projects without providing adequate stand-

ards for payment of an appropriate share of the basic costs by local interests. . . . The Secretary of the Army has previously made suggestions for acceptable legislation on this subject."—Ed.]

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Recent Developments in Water Works Law and Litigation

Edward F. Taylor

A contribution to the Journal by Edward F. Taylor, City Attorney, Redlands, Calif. This paper was a report presented on Oct. 9, 1957, to the convention of the National Institute of Municipal Law Officers, Richmond, Va., by the author, as chairman of the Committee on Municipal Water Problems, and published in the 1958 NIMLO Municipal Law Review.

A STRUGGLE is on for the nation's water resources, and municipalities are in the thick of it. As is always the situation when diverse interests compete for commodities in short supply, solutions are difficult to reach.

Pressure from growing populations makes cities strong competition for industry and agriculture. The phenomenally increasing demands of cities, along with those of industry, cut into the water available to agriculture, which maintains its water use at relatively stable levels.

Water problems alone do much to keep rural-urban animosities alive, although the state of emergency has compelled unity in many instances. For example, farmer, city dweller, and industrialist fight side by side for the prodigious California Water Plan.

Two out of every three Americans live in municipal areas. The essential these people can least do without is water. The nation's population doubled during the first half of this century and added, in the past 5 years, a number equal to the entire population of Canada.

The task of furnishing an abundant and dependable supply of potable water at reasonable cost falls to the engineer. But it is up to the municipal lawyer to protect existing water sources and take the initiative in planning future supply based on firm water rights.

Never have municipal governments faced greater challenges, and never have they leaned more heavily upon their municipal law officers.

Trends in Water Rights

Municipal government agencies welcome the studies currently underway in states confronted with growing demands for water and a need for better means of determining rights. Twenty-one states recently set up special water study commissions or enacted laws affecting the use of water resources. Alaska also plans a water rights study.

Growing steadily and unable to qualify as riparian owners in most situations, municipalities may benefit from the trend to strengthen the appropriative doctrine by legislation and reduce the advantage of location enjoyed by riparian and overlying owners as against appropriators of water for beneficial use on nonriparian and nonoverlying lands.

Rules of law predicated upon an abundance of water must be reevalu-

ated in a time of shortage complicated by booming economic activity and exploding population growth. Whether or not all the states, particularly in the East, will move on to systems of clearly defined water rights depends upon how deeply entrenched is the riparian doctrine and the extent to which existing interests are based upon it.

The attorney general of Georgia, a stronghold of the riparian doctrine, says (*1*): "The riparian doctrine, firmly embedded in our legal history, poses serious questions to the consideration of any prior-appropriation or similar doctrine."

The water law expert, Wells A. Hutchins (*2*), points out that there is no magic in the word "appropriation," and other things being equal, the use of water can contribute to the welfare of the public, or to the interests of individual owners of water rights, whether used on riparian or nonriparian land.

The goal obviously is the highest and best use of water in the public interest, regardless of what water rights doctrine is invoked.

Four states—Iowa, South Dakota, Kansas, and Delaware—recently joined the seventeen western states in declaring that the people have a paramount interest in the use and development of water, both surface and underground, and that the state should guide that development and use for the greatest public benefit, without waste. That the riparian doctrine may be fitted into the overall water rights picture is demonstrated by the nine western states which retain the doctrine as part of their water rights and apply the rule of reasonableness to riparian owners. A type of coexistence of riparian and appropriation doctrine exists in these states (*2*).

Cities may be open to suits by overlying or riparian owners where the law casts municipalities in the role of appropriators and, at the same time, classifies overlying and riparian rights as paramount rights.

In California, the Orange County Water District sued four appropriating cities on behalf of the district's overlying owners in order to claim their paramount rights (*3*). On appeal, the cities contended they act as agents, in effect exercising their residents' paramount rights to pump from the underlying basin. As these residents could transfer their superior rights to the city, the law should imply such a transfer where an owner elects to take water through efficient city facilities rather than the more wasteful method of drilling and pumping on his own land, as he is legally entitled to do. Such conservation, the cities argue, is in keeping with the California constitutional mandate against waste.

Of interest to municipalities is the searching analysis of the Indiana water resources study committee report, pointing up three objections to the riparian doctrine (*4*):

1. It deals only with surface water.
2. Its common-law basis results in decisions on water rights which stand up only as long as another judge and jury do not interpret the facts of the law differently.
3. It applies only to narrow ribbons of land on either side of natural streams and lakes.

The appropriation doctrine generally stamps all unappropriated waters as the property of the state, and the right to use such waters can be acquired by a municipality or any other user only upon application to a state agency for an appropriation permit. The agency, at its discretion, after

notice and public hearing, may grant the permit. Essence of the right is beneficial use, and priority in time confers the better right. The permit constitutes real property, capable of conveyance. The right, once acquired, is more dependable than common-law rights.

Coordination of rights in both surface and ground water supplies is made possible under the doctrine of prior appropriation, which is broad enough in scope to deal with the use of all waters. The West has adopted three procedures for adjudicating rights: [1] civil suits, prosecuted as real estate title contests, with no assistance from state administrative officials; [2] statutory procedures, under which state administrators participate in private suits (California's reference procedure); and [3] comprehensive procedures to adjudicate all water rights by court decision on actions filed and evidence submitted by state agencies (Colorado-Wyoming-Oregon system) (*5*).

Before such procedures take root east of the Mississippi, conditions must impel legislatures to adopt the basic policy that all water within the state is the property of the people and the right to use it shall be appropriated in the manner provided by law.

An editorial from the *New Jersey Law Journal* (*6*), perhaps signaling a new trend of thought in the East, points out:

> It may well be that the growing scarcity of water in the eastern states and particularly in our state of New Jersey would justify a systematic legislative examination of the doctrine of prior appropriation while there may be still time to give it application in the public interest. It is plainly apparent that the common-law doctrine is useful only to determine the conflicting rights as between riparian owners. It does not cover the general rights of the public. . . . In a heavily urbanized state, where adequate water supply must be carried from further and further distances and becomes more expensive by the day, we cannot afford the luxury of failing [to reach] a solution. In this problem, as in most other issues in public affairs, the lawyer has a vital role to invent new legal devices, to negotiate, to evolve compromises based upon reason.

Certainly there is need for modern legislation, supported by facts, clear-cut definitions of water resources terms, and administrative agencies to implement basic policies for the general welfare and assist the courts in future decisions determining beneficial uses and the fair and equitable division of water.

Legislation

In 1955, the Indiana water resources law took a step away from the riparian doctrine by establishing regulation by the general assembly of surface water rights alone. Mississippi followed suit in 1956. That state's water engineer observed that "the majority of Mississippi industries and municipalities use ground water supplies for their operation, and ground water rights are not affected by the Water Rights Act of 1956."

Motivated by the water resources committee finding that the riparian doctrine is no longer completely suitable, the senate of Delaware, a traditionally riparian state, passed a water resources bill providing for allocation of both surface and underground water under a permit system. Action of the house is awaited.

In analyzing the water problems of many Ohio cities, including Spring-

field, Columbus, Akron, Barberton, Greenville, Kent, and Cuyahoga Falls, the Ohio Legislative Service Commission (*7*) stated: "Certain recent developments indicate that in the future there may be more frequent instances in which development of adequate local water supplies is impeded by the common-law approach to water rights law. Chief among these developments are diversion of stream waters, overburdening of ground sources, and irrigation."

A bill introduced in the 1957 Wisconsin legislature and seriously aiming at repeal of the common-law riparian rule was defeated, but a water study committee to consider the advisability of change was set up. North Carolina did precisely the same thing, and Tennessee created a water resources division to formulate basic policies. Despite a citizens' committee's recommendation of legislation to create a temporary commission for the study of Alabama's water resources, the Alabama legislature failed to adopt the bill at both the 1955 and 1957 sessions. Municipal government was represented on the citizens' group, which stated in its 1955 report that a critical appraisal of the state's water rights doctrines "generally leads to the conclusion that they are inadequate because: [1] they tend to discourage water use developments, and [2] they can be made effective only through the processes of court actions. Thus, agitation develops for water use legislation."

Maryland's department of geology recommended legislation to: "modify the doctrine of riparian rights by providing for allocation of water rights to water in excess of the average low flow of a stream to all lands in the drainage basin of the stream." A law to this effect was blocked by the 1957 legislature.

A new Texas law declared illegal the diversion of water released from storage and destined for downstream use, an enactment in line with the state's adherence to riparian tradition as well as prior appropriation.

Evaluations of the merits of the riparian doctrine led to little or no legislation on the subject, but the doctrine of prior appropriation is constantly being shaped by new laws.

In 1957, Oklahoma adopted a policy which climaxed a half century of development of the appropriation doctrine from the territorial statute of 1897 into the full-fledged system of today (*8*). The authority to deal with water law and pollution and administer the comprehensive procedure for appropriating water derived from the 1905 and 1951 statutes is transferred to a water resources board, including a member representing municipal government. The board grants rights to possession and use of public water resources to qualified applicants, but before an appropriated or adjudicated right may be granted for water ultimately to be used at a distant point, sufficient reserves should be set up to meet present reasonable needs in areas of origin. Oklahoma is one western state where riparian rights also may be claimed.

Statutory control of surface and underground waters, no less complete perhaps than appropriation laws, is accomplished in New Jersey by application of the principle of equitable allocation among municipalities, with full jurisdiction in the Division of Water Policy and Supply to conduct hearings and grant applications. The amounts of water that New York City and the states of New York, New Jersey,

Pennsylvania, and Delaware can take from the Delaware River are regulated by decree of the United States Supreme Court (*9*).

Another 1957 statute requires permits for South Dakota municipalities to construct new works for taking water. Application is made to the State Water Resources Commission, which has general supervision of all waters and power to regulate and control water development, conservation, and allotment (*10*).

Neighboring North Dakota recently conferred prescriptive rights upon any municipality which took water for beneficial use from surface or underground sources for 20 years prior to Jan. 1, 1934. Filing or prosecuting an application for such right is no longer required (*11*).

South Dakota's water act was extended in 1955 to cover both surface and underground water by amendment of the earlier laws confined to surface waters. By specific provisions, the law prescribes that the "right of a municipality to acquire and hold rights to the use of water should be protected to the fullest extent necessary for existing and future uses."

Municipal corporations in North Carolina, denied status as riparian owners and left to the exercise of eminent domain for acquiring a water supply, were interested in an act of the legislature proposing a complete transition from the riparian to the prior-appropriation doctrine. Opposition watered the bill down to a mere study proposal.

Studies by the Iowa natural resources council foreshadowed adoption recently of an act installing the appropriative process through a water commissioner, who issue permits for water use (*12*). A municipal corporation aggrieved by the permit may protest in a public hearing and appeal the commissioner's decision. Iowa's farm-dominated legislature, however, closely regulates towns and cities in the new bill, with an advantage going to the farmer, because when cities and towns increase their pumpage appreciably, they must obtain a permit.

The Kansas Water Appropriation Act of 1945, which made surface and ground waters alike in the eyes of the law and adopted the appropriation doctrine, was upheld by a federal court in one of the major decisions dealing with water law in the last decade (*13*). Court sanction of the act was gratifying to the cities of Kansas, which steadfastly resisted repeal or revision of the act. It had marked Kansas's departure from two sets of rules, common law for ground waters and the reasonable-use rule for surface flows.

From the 1957 Kansas legislature came the only major revision of the 1945 law. The appropriation doctrine was strengthened and clarified and the administrative procedure improved. An important feature was the provision that appeal from water rights decisions of the chief engineer must be heard by the district courts in a new trial—a move to counteract objections that the 1945 act denied parties not involved in the original proceedings an opportunity to present evidence on appeal.

In Colorado, where the system of court adjudication and decrees is used to settle water rights, the 1957 legislature allows municipalities to take water from one alternate point of diversion and seeks to remove ambiguities on certain rights. When a decree to water rights is more than 18 years old and the water has been used and the right recognized by designated officials,

no defect in proceedings can invalidate the decree (*14*).

A Wisconsin bill moving toward prior appropriation but suspected of being biased against municipalities was blocked in the legislature. It contained restrictive provisions against withdrawals and may have been the rural reaction to a court decision denying a town's ordinance curbing city use of water. The bill provided, however, for state control of water and a system of permits.

Recent Litigation

Unresolved conflict over water rights can be consummated only in a lawsuit, and there recently has been more than the usual number involving municipalities. By reputation, water suits are long, bitter, and expensive, and they produce no more water than the parties started out with. This background, however, failed to impress the number of water users who spent considerable time in court during recent months pitting lawyer against engineer in battles to the finish.

Following is a summary of the major lawsuits in progress or recently decided:

Rank v. *Krug*

No lawsuit has ever brought a federal-municipal water rights conflict into sharper focus than *Rank* v. *Krug* (*15*). The city of Fresno's complaint in intervention set the stage for Judge Peirson M. Hall's momentous decision that the United States is subject to California water law and that the city was entitled to a declaratory judgment that its rights for domestic and municipal purposes are superior to any right of the United States to divert water beyond the watershed or county in which Fresno is situated.

By virtue of its status as a municipality furnishing water for domestic and municipal uses, Fresno was held to have a preferred position under the California constitution and laws to either the United States or any of the defendant irrigation districts. "This is so by the terms of the watershed and county-of-origin statutes and also by virtue of the statutes of California declaring use of water for domestic and municipal purposes to be the highest and best use," the court declared.

Although entitled to a declaratory judgment denying the United States and the defendant districts the right to divert water presently needed by Fresno, the northern California city was in no position to enforce the right because works had not been constructed to receive the water, according to the court.

Contending that the federal government's operation of Friant Dam as part of the great Central Valley Plan reduced the full flows of the San Joaquin River they previously enjoyed, riparian and overlying owners of land along the river asserted rights to water for reasonable present and prospective uses under federal and California law.

The case stemmed from the United States' refusal to deliver water through Friant Dam to the preexisting users on the San Joaquin River. To justify its denial of compensation to many existing users for their loss and its transfer of water to the southern end of the river valleys for a new class of water user under recent project contracts, the United States claimed the entire flow of the San Joaquin River. The government insisted that its rights to water released from Friant was solely in the discretion and determination of the United States officials who were in charge.

Martz stamps the case as illustrative of federal devices to limit private rights by claiming a paramount proprietary interest *(16)*.

Arizona v. *California*

Several million Southern Californians in the 71 cities depending upon the Metropolitan Water District (MWD) for all or part of their water supply await the outcome of Arizona's action filed in the US Supreme Court against the state of California and several public and municipal corporations, including MWD.

Popularly termed the "long suit," because the end is not in sight after 5 years, the action seeks a cut of 30 per cent of the Colorado River water that California claims under appropriate rights and contracts.

The ultimate question in the case is whether the water rights of MWD and two other existing Colorado River projects, designed to use 5,362,000 acre-ft a year, shall be cut down to make 1,500,000 acre-ft available for Arizona's development. Arizona's nineteen witnesses spent 38 days establishing the state's need of water to expand its economy. Complicating the situation is the fact that every 3 years the California population relying on the Colorado increases by 1,000,000 people, approximately the equivalent of the whole of Arizona's present population.

After California's testimony came the federal government's case, based on theories of paramount rights, particularly on behalf of 80 Indian reservations alleged to have prior rights. Simon H. Rifkind, of New York, conducting the trial, ruled against hearing evidence to back up each Indian claim, because the suit would become "an impossible trial of 80 separate questions," and "I do not intend to take 5 years in trying this case."

Citizens of both Arizona and California await the outcome. Populous Los Angeles, Long Beach, and San Diego depend upon MWD for much of their water supply through the 242-mi Colorado River Aqueduct. Many Arizona cities regard the Colorado River as the key to their future.

Baumann v. *Smhra*

In a decision which attracted the attention of municipalities wherever prior appropriation is practiced, the constitutionality of the Kansas Water Appropriation Act was upheld in *Baumann* v. *Smhra* *(17)*.

States have the power to depart from the common-law doctrine of riparian rights and establish the doctrine of appropriation and application to beneficial use, the court declared.

The complaint alleged that 225 wells—including 25 operated by the city of Wichita for municipal supply—extracted water from an area known as the Equus Beds near Wichita. The plaintiffs were owners of lands located over the water-bearing beds. Water was produced from the wells on the basis of vested-right determinations or appropriation permits issued by the chief engineer. The plaintiffs alleged that the Kansas Water Appropriation Act violated due-process provisions of the Fourteenth Amendment to the United States Constitution by depriving them of property rights. Vested rights are adequately safeguarded by provisions of the act, the court held. The opinion discarded the plaintiffs' contentions that they were unlawfully denied a hearing to protest the appropriation applications and ruled that the act did not require notice to them of the granting of appropriation permits

by the chief engineer. Although valid existing vested rights must be protected by the act and all its amendments, "we do not regard a landowner as having a vested right in underground water underlying his land which he had not appropriated and applied to beneficial use," the opinion continued. Thus, the court declared unequivocally that mere ownership of land entitles no one to vested rights to underlying waters not actually being put to beneficial use. As the plaintiffs did not base their claim of vested right on actual use, their claim was rejected.

Santa Barbara County Water Agency v. *All Persons*

The California supreme court's landmark decision in *Santa Barbara County Water Agency* v. *All Persons,* which struck down federal water supply contracts limiting water for irrigation on the basis of the amount of land owned by the user, directly affected the city of Santa Barbara (*18*).

The city of Santa Barbara was a recipient of water from the Santa Barbara County Water Agency, formed by the state legislature to furnish water. The decision invalidated that agency's master contract to obtain water from the Bureau of Reclamation.

The court ordered the United States to comply with state water law concerning the rights of water users to have service and branded the acreage limitation feature an unconstitutional denial of due process and equal protection of the law.

Legality of the Santa Barbara County Water Agency was upheld, the court rejecting claims that payments to the agency amounted to gifts of public funds and that the agency's taxes constituted levies for nonmunicipal purposes in violation of the state constitution.

Filing of a jurisdictional statement in the US Supreme Court has opened a new chapter in the case, related to the major Ivanhoe Irrigation District decision.

City of Fond du Lac v. *The Town of Empire*

Wisconsin's supreme court stepped between disputing municipalities and struck down a town ordinance virtually barring a city from drilling for water in an unincorporated area. The decision in *City of Fond du Lac* v. *The Town of Empire* (*19*) invalidated Empire's ordinance to prohibit the drilling of wells with a casing in excess of 6-in. diameter and the selling or use of water from wells in the town other than on the premises from which the water was extracted. Fond du Lac had purchased a tract in the town for drilling wells and piping water into the city proper. Ruling out the ordinance because it dealt with water use, a matter of statewide concern, and conflicted with general law, the court opened the way for the city to avail itself of a needed water supply.

A bill putting controls on withdrawals of water and interpreted as the rural interests' reaction to the decision was killed Jun. 28, 1957, by the Wisconsin senate.

Southeast Kansas Cases

A rash of lawsuits followed efforts of Kansas cities to pipe supplemental water from water sources lying without their corporate limits.

Main source for a number of cities in southeast Kansas is the Equus Beds, so named because workers unearthed prehistoric horse teeth when the first

wells were dug. The beds, 10 mi wide, extend 50 mi north and south.

When Wichita sought by application to increase its water take from 25,000 to 50,000 acre-ft per year, farmers united to stop the city's extractions, except on a royalty basis. At least 30 suits piled up, but none has succeeded.

Eight cities and 55 landowners in the area have filed appeals to the district court from orders establishing vested rights. These 63 appeals, all challenging the constitutionality of the Kansas Appropriation Act, are weakened by the decision in *Baumann* v. *Smrha*. After the cities of Augusta and El Dorado joined with three oil refineries to import water from the Equus Beds through the 32-mi line, 49 lawsuits were filed and are still pending. Again, the beneficial use doctrine is under fire.

Orange County v. *Riverside et al.*

In a suit litigating the water rights of agencies serving more than a million Californians, the Orange County Water District secured an injunction against increased water production by the cities of San Bernardino, Riverside, Redlands, and Colton—all located upstream on the highly utilized Santa Ana River.

The action, *Orange County Water District* v. *Riverside et al.* (*3*), features the district's claim of authority under a special statute to sue in a representative capacity for its inhabitants. In the complaint, the district elected to represent only inhabitants having paramount riparian or overlying rights. The court entered a judgment against the cities, on the theory that their rights were inferior to those of the selected proprietors the district represented.

The judge decided that the cities were entitled to no more water than their prescriptive right, as measured by production in 1951, the date of filing. An across-the-board slash of about 40 per cent below 1957 levels was ordered. The drastic injunction was tempered by providing that cutbacks will be delayed 3 years if the cities furnish Orange County amounts of water equal to the quantity used in excess of prescriptive rights or sums of money for the plaintiff to buy an equivalent quantity of water.

Forcing the cities to annex to the Metropolitan Water District clearly is the thrust of the decision, because 3 years happens to be the minimum time that engineers estimate is required to make a physical link with MWD.

The court ruled that the "underground river" was the common source of water for both the upstream cities and the district, although they are separated by more than 50 mi, and agreed that the dropping of water levels, as measured by certain index wells, was primarily caused by water use in the four cities.

On the pending appeal, the cities claim failures to prove responsibility for falling levels in a distant basin or the threat of irreparable damage to support the injunction and an improper determination of prescriptive rights. The court measured prescription on the basis of each facility, including fluctuating wells and abandoned ones, rather than taking into account the total annual appropriation of the city. The cities were forbidden to acquire water from sources within the basin or by means of water stock, although the acquisition of existing stock already in use creates no greater draft on the basin.

A mass of evidence and expert testimony, showing less consumptive use of water by evaporation and transpiration and more return flow to the basin with urbanization and residential development, was rejected.

City of Enid, Okla. v. *Crow*

An appeal by the city of Enid to the Oklahoma supreme court is attracting wide attention, despite the relatively small judgment award, because of the repercussions upon municipalities if the decision is not upset (*20*).

The jury returned a verdict in the sum of $3,811.41 for damages the plaintiffs allege resulted from the operation of a city well near their property. They claimed that city pumping depleted the water supply and drained the well for extended periods.

Grounds for appeal set out in the city's brief include lack of sufficient evidence, errors of law, and improper assessment of damages. The city contends that the municipal extractions complied with the reasonable-use or correlative-rights rule, in that the damage to the plaintiff was minor only and not irreparable.

Significance of the case is epitomized in the brief's concluding paragraph:

> The defendant has dwelled at length upon the evidence not only because of its primary importance to this case, but also because of the precedent that will be set by this decision. The city of Enid, as do many other cities in the state of Oklahoma, obtains its water from a large number of water wells and is seriously concerned about being required to respond in damages for a situation which is due to the drought and other causes over which it has no control.

City of Madison v. *State of Wisconsin*

A 1957 decision of the Wisconsin supreme court (*21*) declared valid an act of the legislature granting the city of Madison the right to fill in a certain section of a navigable lake bordering on the city and to erect thereon a municipal auditorium and civic center. The attorney general's unsuccessful arguments were that the state held the beds of navigable water in trust, for navigation purposes only, that the legislature unlawfully conveyed a valuable right to the city without compensation, and that the term "public buildings" does not include an auditorium and civic center, buildings which have no function relating to the furthering of navigation.

Bino v. *City of Hurley*

A municipality's antipollution ordinance was invalidated for infringing upon riparian rights in Wisconsin. The city of Hurley's regulation prohibiting swimming and bathing on property abutting Lake Lavina, from which the city takes its water supply, was invalidated, because it denied legal rights of riparian owners and took their property without due process (*22*).

Biddick v. *Laramie Valley Municipal Irrigation Dist.*

In Wyoming, an action was brought to determine the water rights of a municipal irrigation district. When the evidence established that the water used was the same originally appropriated for the specific tract, the court decided the water was appurtenant to those tracts and could only be used thereon. The decision barred distribution of the water elsewhere (*23*).

Los Angeles v. *San Fernando, Glendale, Burbank, et al.*

A major lawsuit is developing over Los Angeles' pueblo water right—California's unique contribution to western water law.

Named in the Los Angeles complaint were 214 defendants, including the neighboring cities of San Fernando, Glendale, and Burbank, as well as the state of California itself. The action for declaratory relief, to quiet title to waters and water rights, alleges prior and paramount right to surface and subsurface waters of the Los Angeles River that the plaintiff derived as successor to the pueblo of Los Angeles. An injunction is sought against withdrawals of water from the river or its tributaries or interference with stream flow.

An American city which succeeded a Spanish or Mexican pueblo (municipality) has prior and paramount right to the water naturally flowing through the original pueblo for the use of the inhabitants. The right grows with new inhabitants and city limits expanded by annexation of land not part of the original pueblo. This explains Los Angeles' claim to a right "coextensive with the increasing boundaries and population and the increasing needs for water of said city and of its inhabitants"—a large order indeed in the situation of one of America's fastest growing metropolitan centers.

Summons was issued on Jul. 1, 1957, and the case is yet to be decided.

McMullin v. *Denver*

In a proceeding for an order enforcing a former decree quieting title to reservoir rights, the Colorado courts held that where the final decree to quiet title did not impose an obligation on the city of Denver to deliver water, the plaintiff could not amend the original decree to impose such obligation through a collateral action. The plaintiff sought a contempt citation against the city because of nondelivery of water (*24*).

Frank B. Bowes v. *City of Chicago*

The Illinois supreme court refused to enjoin Chicago from constructing a water filtration plant in Lake Michigan, on the strength of a state enactment authorizing municipalities to construct water purification plants and reclaim submerged land. This act superseded earlier legislation requiring a permit from the state to do work in public waters. Answering contentions that the secretary of the Army's decision that the project did not obstruct navigation was an abuse of discretion, the court explained (*25*): "It is the considered opinion of this court that the construction of the municipal water filtration plant upon the submerged land at the site selected will constitute no materially substantial interference with navigation whatsoever."

City of Seattle Case

A fresh look is being taken by Washington courts into the question of liability of public water supply agencies for damages occasioned by pipeline breaks (*26*). The majority of American courts have held liability will attach only on proof of negligence, and most municipalities operate on this basis.

The rule of strict liability, stemming from the early English case of *Rylands* v. *Fletcher*, was applied by the trial court hearing a damage suit against the city of Seattle after a pipeline

break injured private property. There is no precedent in the state to support the court's holding that one who maintains on his property a thing which would cause injury to others if it escaped is liable if escape occurs, even in the absence of negligence. Seattle was held free of negligence, so liability without fault was the result. The court also appeared to rely somewhat on *res ipsa loquitur*—"the thing speaks for itself."

The pending appeal has general interest because municipal agencies customarily protect themselves against negligent operations by employing personnel who are trained to perform their duties as skilled water utility men should.

Elizabethtown Water Co.

After lengthy litigation, the application of a private corporation for an additional 20 mgd of water from the Delaware and Raritan Canal was blocked by the three New Jersey municipalities of North Brunswick, East Brunswick, and Milltown. They supported New Brunswick's application for more water. The company sought entitlement to half the water rights of the state of New Jersey in the Delaware River.

The municipalities successfully urged that the additional grant to Elizabethtown Water Co. would be inimical to the public welfare and inequitable, because the company already had its fair share of the state's present available supply in an amount sufficient to meet the needs of its customers.

In the same proceeding, the city of New Brunswick's application for additional water to meet daily requirements of its citizens, as well as those of East Brunswick, was granted.

Other Litigation

There were several noteworthy decisions dealing with the liability of municipalities in the operation of water facilities.

In an action seeking damages for increased flow of surface water allegedly caused by a road project of the town of Harrison, N.Y., the court found the plaintiff had not proved that the town should be charged with a material redirection of water drainage or that his land was exposed to flow from areas that had not previously drained onto his property (*27*).

The New Jersey courts recently renounced the common-enemy rule and adopted the reasonable-use theory respecting the liability for use of surface waters by upstream owners.

One decision (*28*) made a substantial breach in the common-enemy rule by stating that there is liability if an artificial device is used to divert water on to a plaintiff's land.

In another decision (*29*), New Jersey completely abandoned the common-enemy rule and adopted the reasonable-use theory. It would seem that the reasonable-use theory will be the new rule of liability for the future, as this decision has already been followed in later ones (*30*).

Owners of lands abutting the Huron River in Michigan did not succeed in enjoining manipulations of a river dam to maintain lake levels when the court found insufficient adverse effect to downstream lands. The owners were left to pursue statutory remedies against the county drainage commissioner (*31*).

An injunction was issued against the town of Everett, Neb., to prevent municipal maintenance of a dike which

flooded a road, making it impassable during heavy rains. In a futile gesture, the town pointed to a statute granting the right to drain where there is a depression or draw 2 ft deep (*32*).

A North Carolina county's hydroelectric dam was put in operation in 1940 and a lower landowner was injured by releases of impounded water. His action filed in 1952 for consequential damages for taking or damaging his property for public use was barred by the 6-year statute of limitations. Greenwood County was granted a nonsuit (*33*).

Injunction was granted against Bay City, Mich., because the parole license allowing the municipality to enter and repair water mains, granted by the landowner's predecessor in title, was deemed revoked by subsequent conveyance (*34*).

Supply and Distribution

Feverish efforts to supplement dwindling water supplies are underway throughout the nation, and municipal government has a major stake in the success of these programs.

Engineering miracles of the past demonstrate that practically any goal of water development is within reach, given time, money, and proper technical and legal advice. For example, the fabulous 242-mi Colorado River Aqueduct delivers water to more than 4,000,000 Southern Californians in a service area of 1,555 sq mi, including 71 cities.

Detroit's system serves a substantial part of Michigan and continues to add service areas. Eight cities in south Oakland County now secure water from an authority formed pursuant to state law, which purchases water from Detroit under a 30-year contract. Alarmed about falling well levels, the city of Pontiac, 25 miles north, now is looking to Detroit for a firm supply. At present, a legal battle is brewing between two factions in southwestern Wayne County which differ sharply on whether water should be obtained from Detroit or a county water system authorized 3 years ago but not yet in full operation.

The multibillion dollar California Water Plan (*35*), described as the greatest water development project in the history of mankind, foundered in the California legislature. Proponents of the plan foresee ultimate success, because water is vital to the state's economy, present and future. In California, 98 per cent of the water supply is in the northern half of the state, while most of the people live in the arid south. Aim of the plan is to distribute properly the northern water, wasting to the sea, to areas of need in the south.

California's water bank account, currently overdrawn by about 5,000,000 acre-ft per year, faces an overdraft of 11,000,000 acre-ft by 1965 unless the plan goes ahead. The plan envisions construction and operation of some 260 new major reservoirs, adding 60,000,000 acre-ft of surface storage capacity to the present 20,000,000. Fully implemented, the thirteen-billion-dollar plan would furnish water in sufficient quantities to expand irrigated agricultural acreage from 7,300,000 acres to 19,000,000 acres, and urban from 1,000,000 to 3,400,000 acres.

On the positive side of the ledger, one bill authorizes the state to assist local public agencies, including cities, in water development projects which substantially conform to the California Water Plan.

Lack of foresight was blamed for the plight of cities put in the position of subsidizing water for agriculture in Utah's Weber Basin. A water conservancy district sponsored by the US Bureau of Reclamation filed upon all water, both surface and underground, not previously appropriated and required all municipalities in an area covering half of northern Utah to pay prices for water sufficient to enable the district to sell below cost to farmers for irrigation.

Pursuant to New Jersey law allowing any municipality or combination of municipalities to form districts to create water supply systems, the cities of Paterson, Passaic, and Clifton carry on a joint operation.

In the booming southern part of Nevada, sources of water supply depend upon whether cities have municipal systems. The Las Vegas Valley Water District, authorized by the legislature to serve only cities without their own systems, furnishes water to Las Vegas, which has no facilities. But North Las Vegas and industrial Henderson must rely upon their own plants. Nevada cities have not been plagued with litigation, although some dispute has erupted in Las Vegas about the district's metering practices. One source of the district's supply is Lake Mead.

The procedure for changing the boundaries of a water district upon a portion of the district being annexed to a municipal corporation is contained in a Missouri senate bill.

Completion of a pipeline thrusting 26 mi to Lake Michigan may have finally ended the years of water crisis in Green Bay, Wis. Short of water for nearly a decade, the city's efforts to increase pumping met legal opposition from adjoining townships, and Green Bay turned to Lake Michigan. Hopes to avoid delay in court were dashed when 4 of the past 5 years were spent defending lawsuits, and a state of emergency was declared banning lawn sprinkling and air conditioning. The pipeline now puts Green Bay in an enviable position.

Municipalities were authorized by the Kansas legislature to contract with each other or with private corporations to establish common water supply. A pipeline 32 mi in length supplies water to the Kansas cities of Augusta and El Dorado and to four oil refineries. So impressed was the electorate with the grave water shortage that the bond issue for the facility passed with 1,477 in favor, against only two opposing votes. Acquisition and condemnation of water rights, land, and rights-of-way, the engineering studies, and bond elections were all accomplished in 3 months. The legislature validated El Dorado's contract to take water through lines of a private petroleum corporation (*36*). Authority to contract with the United States government for the purchase of water from federal reservoirs stems from another act of the 1957 Kansas legislature.

In Michigan, two or more cities with combined equalized valuation of at least $200,000,000 were authorized by the 1957 legislature to join together in an authority for the purpose of acquiring and operating a water supply and distribution system.

Funds earmarked for completion of the water filtration plant being installed by Highland Falls, N.Y., were provided by act of the Congress on May 20, 1957.

Daytona Beach, Fla., installed a well field 5 miles to the west, from which

8 mgd are withdrawn, despite danger of pollution, especially from salt water intrusion.

By virtue of an enactment of the 1957 Pennsylvania legislature, water supply authorities may be organized by one or more counties for the sole purpose of water supply, and any municipality may enter into contracts with the authority for the purchase of water.

The intent of the Virginia general assembly that municipalities shall use such water as may be needed for an adequate water supply system has been carried out in recent municipal charters in that state (*37*). These charter provisions are not uniform, and vary between wide limits. The charter for the city of Norton includes the power: "to own, operate, and maintain water works and to acquire in any lawful manner in any county of the state such water, lands, property rights, and riparian rights as the council may deem necessary for the purpose of providing an adequate water supply." The charter for the city of Covington gives that city the power: "to acquire, construct, own, maintain, and operate, within and without the city, water works," but it does not refer to water supply (*38*).

With consent of their governing boards, or upon petition of a majority of freeholders, cities and towns are included in Indiana conservancy districts for providing potable water, sewage disposal, and other facilities, pursuant to 1957 legislation (*39*).

To safeguard its water sources, the city of Dover, Del., has an ordinance providing that no wells may be drilled to a depth of 150 ft or more without approval from the city. Dover obtains ground water from a Miocene aquifer, and water levels have declined substantially in recent years.

A 1957 Maine statute (*40*) requires the public utilities commission to approve costs of construction of water systems, methods of finance, and engineering standards before any municipality may commence construction of a new water plant or make major additions or changes in any existing systems.

The cities of Beverly Hills and Redlands in Southern California reissued streamlined water codes, regulating water service connections, water rates, and payment of water bills in new subdivisions and prohibiting waste. Annapolis, Md., promulgated new provisions for constructing and financing water connections to new homes, whether built by private owners or developers.

Referred to the congressional committee on public works was a bill authorizing the use of a limited amount of storage space in Lake Whitney to supply water to nearby Texas municipalities.

Arkansas cities now may seek across the state's borders for sources of water. The 1957 legislature authorized them to acquire land or water supplies in adjoining states "to have a safe and satisfactory water supply." The state's municipalities were empowered to institute eminent domain proceedings for obtaining sources of water supply, and two or more municipalities may join in such activity (*41*).

The drought and increasing pollution of the Little Arkansas and Big Arkansas rivers, normal sources of water for Wichita, Kan., has forced construction of a pipeline to the Equus Beds, northwest of the city—an act which plunged Wichita into protracted litigation.

Illustrating the dependence of the most remote communities upon the far-flung Missouri River system, serving nearly 2,000,000 people, was an application filed for rights to the river's water by Williston, N.D., located in the northern part of that state.

New Hampshire provides that municipalities may increase their bonded indebtedness to 10 per cent of their last equalized valuation for the construction, enlargement, and improvement of water utilities (*42*).

Water scarcity has turned attention more and more to the reuse of water. Where municipal outfall disposal plants produce effluent suitable for irrigation, questions arise as to who has right to the water. In the absence of court decisions or laws on the subject Salt Lake City has successfully argued that when the city appropriates it, the water becomes personalty, subject to personal property rules; once delivered to purchasers, the water becomes their personal property, and is subsequently abandoned. When subsequently abandoned, the water is accepted by the city in its sewage collection system and again becomes city personalty, which it may sell or use as it sees fit.

This survey of supply and distribution would be incomplete without mentioning salt-water conversion (*43, 44*) and cloud seeding (*45 46*). If these programs are ever adopted on a wide scale, water law attorneys will be busy advising municipalities on associated matters, ranging from contracts, real property, and tort liability to enabling legislation.

Outside-City Water Service

The runaway growth of population centers has led to demands for municipal water service to overlapping points outside the corporate limits. Where supply and requirements permit, does the municipality have a duty to grant and service outside connections? Ohio and Montana expressions on the subject leave the matter undecided.

Section 6, Article 18, of the Ohio constitution provides:

> Any municipality owning or operating a public utility for the purpose of supplying the service or product thereof to the municipality or its inhabitants may also sell and deliver to others any transportation service of such utility and the surplus product of any other utility in an amount not exceeding in either case 50 per cent of the total service or product supplied by such utility within the municipality.

The major cities of Ohio have sought an amendment to this section removing the 50 per cent limit on water service. The general assembly recently proposed such an amendment to be submitted to the voters. The cities objected, however, to control by the state legislature and succeeded in obtaining an injunction against the election authorities on technical grounds to keep the proposal off the ballot. The court of appeals dissolved the order, and the case is now before the Ohio supreme court. Present status of the municipal water law in Ohio is unsettled, with the constitutional provision apparently controlling.

An opinion of the Ohio attorney general this year upset the view of many an Ohio municipal counsel that municipal corporations, being analogous to public utilities, are compelled to serve all persons with property adjacent to water service lines. Many subdivisions which counted on the city of Warren, Ohio, for water service may be left high and dry, because of the attorney general's decision that adja-

cent landowners, outside the city, do not have the absolute right to tap into water mains in the absence of authority from the municipal corporation. This authority the people outside Warren may not be able to obtain.

Water users in unincorporated areas in Montana may rely upon cities and towns with somewhat more confidence. Municipal corporations are empowered to furnish water outside with no change in rate if delivery is made within or at the corporate limits. Rates for delivery at outside points by cities must seem just and equitable to the city council.

A Florida city's agreement to deliver water outside the corporate limits to a federal installation was approved by the court. In a proceeding to determine the validity of water revenue bonds for the extension of the city of Cocoa's service 20 mi under a $4,000,000 contract with the US Air Force, the court held there was no abuse of discretion in view of the fact that the bonds were payable solely from revenues and there was no other source of urgently needed water (*47*).

In an action to enjoin the city of Grandview, Wash., from charging nonresident customers of its municipal water system a rate in excess of that fixed for residents (50 per cent higher than the rate for resident users), the city was held to be entitled to establish for rate-making purposes a separate class of nonresident water users; such rates were considered nondiscriminatory. Any rate may be applied to nonresident users as long as the rate is reasonable. The court observed that the cost of rendering service to nonresidents is greater than to residents, and this is true not only in respect to reading of meters, but also in servicing and repair of lines (*48*).

Recent court decisions in Virginia concerning the responsibility for supplying water to persons outside of the corporate limits hold that a municipality is obliged to continue to serve the outside area. But there has been no unanimity of opinion in those situations in which a municipality was the original builder and has been the only owner of the system, as distinguished from areas being served both within and without the corporate limits which the prior owner had served.

A city cannot be compelled to furnish larger mains for transmission and distribution of water to residents of a rural special improvement district outside limits of the city to provide adequate services for such nonresidents, the Montana courts ruled (*49*).

New Jersey courts apparently now hold that incidental service by a municipality to nonresidents cannot be converted into obligation (*50*).

Cities and towns are authorized by the 1957 Washington legislature to execute firm contracts to furnish water to any outside municipality, community, corporation, or person, whether or not such water is considered surplus.

Eminent Domain

A municipal government rarely is in a position to claim riparian rights, which are necessarily confined to narrow fringes of land bordering on bodies of water.

Eminent domain is virtually the only recourse of many municipalities in the East and in those western states recognizing the riparian doctrine, and for that reason, a review of recent developments in water rights condemnation may be instructive.

A 1957 Arkansas act (*51*) grants cities the authority to condemn any

property "useful for municipal water works purposes." The legislation sets out a detailed procedure in eminent domain and permits the flooding of state or county roads or the facility of a utility, provided the municipality stands replacement costs.

Municipal authorities operating water projects may condemn entire tracts when necessary to acquire a part of the tract for water projects. The court held that under Pennsylvania law the municipal water authorities have discretionary power to determine how much land is to be acquired. The authorities' determination of the amount of land to be acquired will be reviewed by the court only when fraud, bad faith, or abuse of discretion exists. In the Truitt case (*52*), the water authority condemned the 189-acre tract after attempts to purchase 140 acres were unsuccessful.

When the city of Seattle sought to acquire land of the state of Washington for construction of a dam and reservoir for city water supply from the Tolt River, the city attorney held that Seattle could resort to condemnation. The opinion states that:

> The mere fact the state owns certain land and has the right to devote it to a public use is not alone sufficient to withdraw it from the broad powers of eminent domain conferred upon cities. . . . An unripened intention to use such property for any specific purpose must give way to an immediate and definite public use proposed by a municipality.

In an unusual application of eminent domain, West Virginia empowers its state water commission to authorize private interests to condemn property for pollution control, such as land for industrial-waste treatment plants.

In Washington, a third-class city was entitled to an order adjudicating a public use in a condemnation proceeding to acquire a right of way 30 ft wide for a pipeline connecting the municipal water system to a city well outside the corporate limits. As no constructive fraud was proved in respect to the city's selection of its proposed route for the pipeline, the general rule was applied, the court being bound by the legislative determination of the city council that the taking or damaging of certain land was necessary for the contemplated project (*53*).

Fluoridation

The furor over fluoridation of municipal water supplies has subsided somewhat. A line of decisions in seven states accepts fluoridation as a reasonable measure to prevent tooth decay and places the practice within the police power of both general-law and charter cities. Although the legality of fluoridation is settled, it will probably linger as a policy matter to plague legislative bodies for years to come.

Ordinances intended to promote public health by providing for fluoridation have been upheld, despite contentions that they infringe upon individual liberty and religious freedom, subject people to compulsory medication, and take away parents' control over their children's health, and that dental care is a private health problem, not a proper object of government. The courts also reject arguments that fluoridation is discriminatory or constitutes the illegal practice of medicine.

California was the scene of a recent skirmish. In an unprecedented ruling by the public utilities commission, the city of Oroville was allowed to compel a privately owned public utility to add

fluorides to water delivered to the municipality. The commission rejected the defendant Water Service Co. position that: [1] water water supply affected was not actually owned by the city; [2] fluoridation is an unsafe, compulsory medication; and [3] fluoridation is unacceptable to certain religions, and forcing it on members violates the first and fourteenth amendments. Expert testimony of health benefits from fluoridation supported the city, and the commission explained "that no person may, by exercising his religious belief, infringe the sovereign power of the state to provide for the health, safety, or general welfare of its citizens."

McQuillin suggests (*54*) that fluoridation might be further justified as an exercise of the proprietary power of a municipality to serve the needs of its inhabitants. To date, no decision rests on this basis.

In direct state action on fluoridation, the 1957 Maine legislature forbade any utility to add fluoride to water supply without authorization from the municipality or municipalities served by it (*55*). Approval by cities requires majority vote of the legal voters, or a majority vote of inhabitants present at the annual town meeting. In New Hampshire, the legislature authorized fluoridation, provided a public hearing is held before any fluorides are added.

The city of Detroit recently directed the municipal water board to fluoridate the water supply and charge the expense to all water users.

Conservation

A local phenomenon of the past decade has been the mushrooming of small watersheds as the primary social and economic unit of water development, management, and conservation. Municipalities within or adjacent to watershed units are vitally concerned with the maintenance of water tables, local water supply, pollution abatement, flood control, and other benefits afforded. Typical is the Little Arkansas River Watershed District, created by the 1957 Kansas legislature to serve seven counties. It meets the requirements of a watershed by comprising all or a reasonable portion of a natural drainage basin and being large enough to be effective and small enough to be manageable. Amendments to the 1953 Watersheds Districts Act in Kansas tended to facilitate organization of districts (*56*).

Supporters of the program on a national scale are the US Soil Conservation and Forest Service projects and the Watershed Protection and Flood Prevention Act. People living in the small watershed initiate the project and help develop the work plan. Community organizations apply for aid and participate in financing and constructing the projects. The entire program has grass roots strength, based on essentially local enterprises supported by federal participation, not federal projects with local participation.

Florida, where drainage problems demonstrate a pressing need for watershed management, authorized counties to contribute funds toward the preparation of surveys by the federal government as part of the watershed program.

Oregon cities are authorized by 1957 legislation (*57*) to protect their watersheds by prohibiting or restricting trapping, timber harvesting, or mining, but may permit such activities upon conditions specified in an ordinance. Where the watersheds are on

federal lands, the city must effectuate the local regulations through agreement with the proper federal agency.

Lincoln, Neb., vests in its mayor the power to impose reasonable restrictions on the use of water, with turnoff orders being sanctioned.

A phase of water rights studies soon to be undertaken by the territory of Alaska is the proposal of legislation to safeguard and insure water supply for the territory's municipalities.

Indiana's new and thorough conservancy act (*39*) sets up districts to provide flood control, water supply for public use and sewage treatment and disposal, and specifies that cities may be part of a district.

To conserve underground waters, the city of Oxnard, Calif., prohibits the penetration of water-bearing gravel underneath the city unless a permit has been obtained and standards have been met for the prevention of waste.

Conservation is a major objective of Mississippi's Tombigbee Authority, embracing ten counties, Pearl River Industrial Commission, covering five counties, and Pat Harrison Waterway Commission, linking eleven counties.

Minnesota added a comprehensive watershed act in 1957, providing for contracts with the federal government and other agencies and the assessment of benefited private owners for cost of improvements (*58*).

Virginia (*59*) and South Dakota (*60*) now have joined the increasing number of states requiring caps on flowing artesian wells which have been abandoned. The person failing to prevent such waste faces a fine or jail term and a bill from the director of conservation to cover the expense of capping if it is necessary for the director to do the job. Measures for conserving flood waters may enable many municipalities to add to storage. Municipalties which own land may capture and impound diffused surface waters for later use in Virginia, Kentucky, Iowa, Arkansas, Delaware, and Florida.

Nonconserving water-using installations have been tagged with a special rate of $7.50 per year per ton of capacity in Detroit, Mich. The charge is designed to pay for the water plant that lies idle 8–9 months of the year, when air-conditioning units are not in use. A group of consumers filed suit contesting the legality of the new charge, citing as grounds unlawful discrimination and a rate structure that was already too high to warrant increase.

The Georgia general assembly recently created a water resources commission, with a state water engineer acting as executive officer and adviser, in a program to develop, utilize, and conserve the state's water resources "prudently to the maximum benefit of the people." A representative of municipal government sits on the commission, which must cooperate with municipalities in regulating and conserving the use of water. The engineer's first task is an inventory of the state's water resources.

Before constructing works for taking water, municipal corporations in South Dakota must apply for a permit from a water resources commission, which has general supervision and control over the development, conservation, and allotment of all waters of the state (*61*).

Cooperation with local governmental organizations for the purpose of utilizing and conserving the waters of the state of Florida is the aim of 1957 legislation (*62*) setting up a department

of water resources. The bill is limited to surface waters.

Water Pollution

That conservation of water must be linked with quality control is understood by municipal authorities everywhere. The need is not only for water in quantity but for water of reasonably good quality, and municipalities, as water users and potential sources of pollution, are definitely in a key position.

Although municipal water is kept safe, the possibility of impure water entering public supply is cause for concern where growing sewage loads are coupled with obsolete or inadequate facilities.

Pollution abatement laws bear down hard on municipalities in many states. These statutes usually authorize a state health agency to revoke permits to discharge wastes into waters of the state, refuse to issue them for new points of discharge, and order construction of needed treatment facilities. Hearings must be held before orders can be issued.

Kansas cities have completed 44 sewage treatment plants since 1947, not counting several plants currently under construction (*63*). Authority from the Kansas legislature to levy sewer service charges helped in the financing. To provide cities along the Missouri River main stem with sewage treatment, Kansas, South Dakota, Nebraska, Iowa, and Missouri have launched a cooperative program expected to cost at least $100,000,000. The Missouri River supplies 1,800,000 persons with water and absorbs the waste load from 4,300,000 persons.

Municipalities in seven southern states are subject to orders to quit discharging fecal wastes by authority of an interstate compact. This grand approach to pollution control and reduction is the Tennessee River Basin Water Pollution Control Compact, involving Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia. The compact calls for surveys of pollution conditions and authorizes the control commission to render advice to municipalities and recommend solutions.

On Feb. 13, 1957, the USPHS announced grants totaling $3,883,535 to 60 municipalities building sewage treatment works under the new Federal Water Pollution Control Act. The 60 cities and towns, ranging from 280 to 250,000 in population, added $11,870,688 of their own funds, to bring the cost of the sewage treatment facilities to a total of $15,754,223. Congress later authorized federal grants of $50,000,000 a year (up to an aggregate of $500,000,000) for municipal sewage treatment plants. It limited individual grants to $250,000 or 30 per cent of the total cost of the project, whichever is less. To qualify for federal funds, the municipal project must be a part of the comprehensive control program developed by the USPHS, other federal agencies, and state and interstate water pollution control agencies (*64*).

On the other hand, municipal government keeps a wary eye on industrial and agricultural operations. The Midwest, evidently, has discovered irrigation and thus introduced a new source of contamination, as well as fresh drafts on the water supply.

Not generally realized is the deleterious effect of air-conditioning plants upon water quality (*65*). Where the plants operate from drilled wells and return the water underground, contamination may result, and many cities

are considering legislation. The city of Waterloo, Iowa, has expressed considerable anxiety about the problem, as has the Michigan State Water Resources Commission.

The Nebraska legislature recently enacted a pollution control program for public water supply, administered by a board with members representing both industry and municipalities, and a recent amendment puts representatives of both municipal and county government on Alabama's Water Improvement Commission.

Disposal of industrial wastes is of major concern to municipalities, which often must handle the waste and then worry about the damage it does to municipal supply.

In Michigan, for instance, pollution of city wells occurred at Edmore (salt waste from nearby pickle-brining stations), at Alma (phenol from oil refinery waste-burning pits), at Douglas and Grandville (chromates from plating plants), and at Lansing (picric acid from a chemical plant) (*65*).

West Virginia, which since 1929 has curbed pollution by municipalities, extended its control to coal washery waste, a major source of contamination in the past. The 1955 voluntary cooperative program, joined in by virtually all the coal companies of the Coal River basin, now is paying dividends in cleaner water for West Virginia.

A city's discharge of sewage was upheld by a New Jersey decision (*66*), which applied the reasonable-use rule to riparian rights, holding that the discharge of treated sewage effluent into a running stream is not, as such, an unreasonable use of the stream.

In an action for damages caused by a city depositing raw sewage in a stream, an injunction was issued because an abatable nuisance was shown, but damages were limited to the injury sustained (*67*). In Illinois, the city of Murphysboro was ordered to cease discharging its untreated sewage into a river under authority of the Sanitary Water Board Act (*68*).

Sued for damages to a lower riparian owner caused by sewerage, the city of El Dorado Springs, Mo., was liable even though it had appropriated the right to dump sewage into the water in 1903. As the nuisance did not begin until 1952, the statute of limitations did not bar the action (*69*).

The water pollution commission's order halting a New Hampshire town's discharge of raw sewage into the Piscataguog River was held constitutional and enforceable by injunction, fine and contempt (*70*). In denying an action by taxpayers to restrain the commission from enforcing its order requiring Goffstown to refrain from discharging untreated sewage into a river, the court said (*71*) that the order was a valid exercise of the police power and found the authorizing statute reasonable.

The intent of 1957 amendments (*40*) to the Maine revised statutes was to place the responsibility for purity of water supply in the Department of Health and Welfare, for drainage and sewerage in the Water Improvement Commission, and for the construction of water systems and rate fixing in the Public Utility Commission. The three departments previously had interlocking responsibilities which needed definition. The water quality classification to guide the Water Improvement Commission ranges from Class *A*, allowing no discharge of sewage or waste, to Class *D*, waters primarily devoted to transportation of sewage and industrial wastes. The Department of Health and Welfare must examine all new water supply and puri-

fication plants and consult with and advise municipal authorities as to the most appropriate source of water supply and the best method of assuring its purity.

New Hampshire now extends its credit unconditionally to municipalities constructing sewage disposal plants designed to effectuate pollution control in state waters.

Safeguarding of local water supplies was the goal of the 1957 Arkansas legislature, which declared it unlawful for any person to wade, bathe, or swim in any lake or reservoir or nonnavigable stream lying above the water intake or impounding dam of a municipality or water improvement district. Reservoirs or lakes with a surface area exceeding 700 acres are excluded (*72*).

The 1957 session of the Georgia and Missouri general assemblies marked the adoption of comprehensive water quality control acts (*73, 74*). Enforced by the state board of health, the act provides for the regulation of public water supply treatment facilities and prohibits the discharge of sewage, industrial wastes, or other wastes adversely affecting public health or rendering such waters unsuitable for current uses. Violations are punishable. A policy-making water quality council of eleven members, including a representative of municipal government, makes recommendations to the board.

A Madison, Wis., ordinance prohibits dumping substances into lakes, rivers, streams, or drainage ditches without consent of the city council or the state, and provides a penalty and civil liability for cost of removal.

Water Rates

Rates charged by the federal government for water supplied to a California city must meet the same test of reasonableness applied to water rents charged by municipalities, a United States district court judge held, in the important case of *Rank* v. *Krug* (*15*). The federal rate must be reasonable and not in derogation of state law, the opinion declared.

Finding that federal rates to certain irrigation districts were less than the city of Fresno paid the United States for water for domestic and municipal use, the court said:

> If the United States can compel the city of Fresno to pay whatever charges it chooses, then it can do the same thing to every other city in California (and the United States for that matter), after it has erected a dam and impounded the water of rivers adjacent to or near cities, upon which the civilization and economy and the future of such cities are founded. The city of Fresno is entitled to a declaratory judgment that any charge for water which may be made by the United States should be reasonable.

The California water code in Section 106 provides that use of water for domestic purposes is the highest and best and that the rights of municipalities are to be protected to the extent necessary for existing and future requirements.

Three water rate cases decided in Pennsylvania merit the attention of municipal law officers. In the first case (*75*), a water company sought to include in its rate base the value of land presently used by it as reservoirs at the theoretical value that the land would have if it were used for the same purposes as nearby residential or commercial properties. The superior court, in affirming the decision of the utilities commission, said that the commission acted properly in disregarding the testimony on the theoretical value of the property and including in the

rate base only the original cost of the property to the water company.

The second case (*76*) involved a water user in the city of Philadelphia who questioned a city ordinance regulating the use of water meters. The Supreme Court of Common Pleas of Philadelphia County held that it was entirely proper for the city to require the consumer to bear the cost of the water meter and at the same time for the city to regulate the type of meter to be used, to determine the supplier of the water, and to require installation of the meter by the city.

In the third case (*77*), a water company challenged the right of the utilities commission to suspend a rate increase for the statutory period on petition of the city of Pittsburgh. The rate was set by a contract between the water company and the city of Pittsburgh, which purchased the water from the company and resold it to consumers. The Court of Common Pleas of Dauphin County held that a rate set by contract was a rate subject to approval of the utilities commission and could not be changed in contravention of the law. Therefore, a suspension of the rate contrary to the terms of the contract, but in accordance with the rate regulatory statute, was proper.

Cooperation

The number of conflicts involving municipal corporations and other governmental agencies competing for the nation's water supply must not obscure the many examples of cooperative endeavor.

Outstanding teamwork can be reported in Michigan, where cities miles from Detroit formed authorities to secure water from that city; in California, where 71 member cities of the Metropolitan Water District rely upon that agency; and in Kansas, where the approach adopted by two cities deserves mention.

To combat the extreme water emergency in Kansas, a pipeline 32 mi long was installed to supply water to the city of Augusta, city of El Dorado, an oil refinery at Augusta, and two refineries at El Dorado. In constructing the $1,250,000 line, the three industries and two municipalities united to overcome grave legal obstacles, including lack of authority to condemn land beyond 20 mi of the corporate limits, prohibitive bonded-debt limits, questions of whether common-law rights were affected, and the lack of legal basis for joint ownership of a utility by two or more cities, or cities and private corporations. The problem was solved when each city and each industry agreed to own segments of the line and transport water through the various segments by mutual operation. And in the last session of the legislature, these cooperating groups sponsored the law enacted to permit industry and municipal government to own utilities as tenants in common.

As the direct result of state legislation, two or more cities may cooperate in forming authorities to acquire water supply in Michigan and to exercise eminent-domain proceedings for the same purpose in Arkansas. Kansas legislation allows municipalities to contract with the United States for water from federal reservoirs.

Theatened pollution of waters for domestic and municipal use impelled political units to band together for the enforcement of strict health standards and pollution abatement measures, and the result was such cooperative programs as the five-state program for the

Missouri River, the Tennessee River Basin compact involving seven states, and municipal cooperation in Mississippi, previously described.

It is in the field of conservation that the United States has cooperated most closely with municipal authorities. Specifically, the Watershed Protection and Flood Protection Act of 1954 (*78*) shifted the major initiative for selecting, planning, constructing, and maintaining projects from the federal to the local level. Counties and other forms of local government may be designated by the state to undertake the programs and quality for state and federal grants.

One of the most recent watershed districts is the Little Arkansas River Watershed District set up by the Kansas legislature. The program is designed to fill the gap between projects to conserve water and soil on farms and the big developments on major rivers, emphasized by the national government in the past. The answer was the watershed unit.

Water for municipal and industrial purposes is given priority over all other uses in recent project authorizations by the United State Congress. Two examples of such legislation are the Colorado River Storage Project (*79*), to promote the comprehensive development of the water resources of the Upper Colorado River Basin, and the San Angelo Project (*80*), directed toward optimum utilization of the available water resources of the San Angelo area in Texas. An object of the latter program is increasing the firm water supply for the city of San Angelo from 15,000 acre-ft to about 29,000 acre-ft per year and providing flood protection and recreational opportunities in the vicinity of the city.

Congress granted money to Highland Falls, N.Y., as part of the financial outlay for the city's new water filtration plant, and has taken under consideration a proposal to let Texas municipalities use storage space in Lake Whitney to supplement local water supply.

Joint financing of federal-state projects with major outlays of money for municipal water has been proposed by Representative Clair Engle, chairman of the Committee on Interior and Insular Affairs, House of Representatives. Explaining the proposal, Engle points out that existing federal water programs have "one obvious gap: no provision exists in present Federal law for the Federal Government's participation in projects primarily for the development of industrial and municipal water, which is a field of growing importance in all areas of our nation." The chairman expects to propose legislation under which the United States will advance, on a nonreimbursible basis, the amount of money in such projects charged to flood control, and interest-free loans for amounts allocated to irrigation.

Conclusions

The survey points up these recent developments in the water problems of municipalities:

1. Water scarcity is growing more acute and spreading; it is no longer a sectional problem, but a national one.

2. Pollution is confounding efforts to reuse and supplement water supply.

3. Legislatures are slow in shaking off traditional water rights concepts to adopt comprehensive laws for coordinating both surface and underground waters.

4. Conflicts between municipal, state, and federal authority are reaching agreement on many occasions, but leading to court battles on others.

5. Lawsuits and legislation aimed against municipal corporations are succeeding many times for their anti-urban sponsors.

6. Water development is lagging behind demands of the population boom.

7. Plans for supplemental water are progressing despite profound legal and engineering problems.

8. Outside water service, eminent domain, and fluoridation continue as problems of municipal supply.

9. Conservation measures are increasing.

The causes of conflict and problems over municipal rights in water seem to arise from the following problems:

1. Extractions, which contribute to drawdown or lower ground water levels, causing well failures and damage

2. Pollution of ground water and stream flow

3. Water supply deficiency, resulting from drought or increased production

4. Unpredictability of the water resources from season to season, and the obscure behavior of water underground, making proper legal precautions for the future virtually impossible

5. Uncontrolled use by everyone with little or no regard for the rights and needs of other users.

Future generations will be indebted to the municipal counsel who can spot and nullify the factors that trigger a water suit, involving the municipal user as either plaintiff or defendant, and who can draft clear and practical solutions in the form of new laws.

Municipal lawyers should be in the vanguard of those urging legislation to bring order out of chaos in water rights. Uniformity is not an end in itself, but the goal certainly is a comprehensive program to coordinate rights in surface and ground water supplies and procedures for the adjudication and administration of firm water rights on the basis of reasonable beneficial use. The challenge will be all the harder for municipalities which enjoy unrestricted water use for the time being. The need to provide today for the water law problems of the foreseeable future calls for statesmanship and planning.

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Developments in the Design and Drilling of Water Wells

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A paper presented on Oct. 31, 1957, at the California Section Meeting, San Jose, Calif., by Samuel T. Guardino, Supervisor, Design and Field Operation, Western Well Drilling Co., Ltd., San Jose, Calif.

NOT many years ago, the origin of underground water was a matter of speculation; it is now realized that the underground water supply is directly dependent upon the annual recharging by winter rains and snows of vast, natural, underground reservoirs. California's growth—industrially and agriculturally—requires that great amounts of water be utilized from these reservoirs, and obligates industry to preserve the quality of these waters for posterity. It is the duty of the well-drilling industry to design and construct wells that will render efficient service yet protect and conserve the natural resources so essential to economic progress.

In most of California, the natural reservoirs or aquifers consist of large bodies of saturated sand and gravel through which water flows at extremely low velocity. Experiments have indicated that this velocity is 2–10 ft per day. When a well penetrates one of these aquifers and water is removed by pumping, the velocity adjacent to the casing increases rapidly. This rapid increase in velocity is responsible for the movement of sand and fine material simultaneously with that of the water being extracted. Most well failure, pumping-plant inefficiency, and excessive water production costs can be directly attributed to excessive sand pumping. Proper well design, therefore, should eliminate or greatly reduce sand intrusion. Such a design must not only restrict the flow of sand but must be capable of supplying all of the desirable underground water available.

Gravel Filter

In an effort to reach this goal well-drilling contractors commenced constructing a well which utilized a gravel filter. These first gravel type wells were constructed by the cable tool method by one of the two following procedures. The first involved the use of two casings with gravel placed between them. The external casing was 4–6 in. larger in diameter than the inner or flow casing and was perforated at all water bearing formations encountered during its introduction into the well. The inner casing was perforated throughout its length and set into the well after the outer casing had been landed at its final depth. Gravel was then introduced between the two casings for the entire depth of the well. Sometimes the external casing was then removed but, more often, it was left in the hole because removal was either impossible or impractical. It has been found that if

both casings are left in the well the permeability of the gravel decreases rapidly because of cementation or clogging of the pore spaces within the gravel. This type of construction is quite costly and offers little probability of producing the desired results. The second method uses a starter ring several inches greater in diameter than the casing. This is attached to the lower end of the casing starter section in order to cut a hole of larger diameter than the starter section. The well is drilled by the percussion method in a manner similar to that used for a regular cable tool type well. During this process, gravel, inserted between the external surface of the casing and the surface which is actually the limit of the bore cut by the oversize starter ring, moves simultaneously with the casing as it is forced downward. This method of construction is still in use in many sections of California. The disadvanatges of this kind of construction will become apparent as the rotary method of gravel envelope construction is described. Practically all gravel envelope wells today are drilled by the hydraulic rotary method. The popularity of this method has increased to the point where—in areas where proper construction standards are maintained by reliable contractors—approximately 75 per cent of the wells are rotary-drilled gravel envelope designs. The gravel envelope well is designed on sound engineering principles and provides for the extraction of underground water at maximum rates while retaining the natural sand and gravel reservoir. This design is based on the theory that the transmission of sand with water decreases proportionately as the diameter of the well increases. The primary purpose of the gravel envelope design is to render possible the use of a large-diameter bore. It would not, however, be economically or physically practical to drill wells to any great depth and case the entire length with large diameter casing. The gravel envelope type well drilled by the rotary method makes a large diameter well practical by employing casing—the gravel—of sufficient diameter to carry the anticipated flow and accommodate the anticipated pumping. Although the primary purpose of this kind of well is retention of the desirable bore diameter by the use of the gravel, many other advantages are inherent in its construction. In order to illustrate these advantages, the hydraulic rotary construction of a typical gravel envelope well will be described.

Test Bore

The first phase of construction consists of the drilling of a test bore of adequate diameter to allow removal of 1 cu ft of sample from each foot of hole drilled. A 14-in. diameter bore will remove 1.2 cu ft of material for each lineal foot of hole drilled. If the test bore is of ample size and is not drilled with excessive downward thrust, the resulting well will be as straight as is consistent with the best drilling practices by any method of construction. The test bore is made to determine the probability of obtaining a productive well and to determine the exact cost of the completed project. If the indications of the test bore are favorable, the following design characteristics can be accurately determined: the depth at which the well should be completed, the size and elevations of perforations, the size of gravel to be used for the envelope, and the location of a clay formation of sufficient impermeability to seat a control

casing for the exclusion of undesirable formations.

In an area where formation samples may be deceiving and where a more accurate log is required, it is possible to contract for an electric log of the test bore. It is sometimes difficult for even a very experienced operator to ascertain the exact elevation at which a formation change occurs with either a cable tool or a rotary-type drilling machine. An electric log will indicate the exact elevation at which the formation changes occur. This log, by furnishing a graphic recording of the relative resistivity of the formations encountered, indicates their permeability. It is also possible with electric logging to locate chloride intrusion and the exact elevation at which it occurs. The log is kept by many drilling contractors and owners as a permanent record and, in the event of salt water intrusion at some later date, the contractor can determine from it the elevation of the formations which would probably be responsible. This eliminates the excessive cost of isolating each perforated area in order to determine where sealing should take place. Because this is a highly technical service dependent upon proper interpretation, explanation and interpretation of electric logging should be done by a qualified representative of the companies that perform the service.

When it is essential to obtain truly representative samples in an uncontaminated form, core samples may be taken as the test bore is being drilled. This type of logging is time consuming and costly, and is recommended only when geological information of a very exact nature is required. It should be mentioned that the unconsolidated formations—the most important source of underground water—are the most difficult to retain in a core barrel.

If a test bore indicates the advisability of abandonment of a well because of the improbability of its being productive, the loss is negligible because casing or other materials have not yet been employed. If a test bore indicates that a well may be completed at a lesser depth than that contemplated, it is necessary to complete only that portion of the well which appears to be the major source of supply. With percussion or cable tool construction, it is necessary to case the well as it is being drilled. Therefore, unless a test bore is made before construction, expensive cased well must be used to explore beyond the depth of the last water bearing formation encountered. Because it is usually impossible to recover this casing, the lower nonproductive portion of the well is rendered useless and constitutes an unnecessary expense.

Surface Seal

To industries such as that of well drilling, so dependent upon future sources of underground water, proper precautions to preserve the quality of water in underground reservoirs is imperative. Reliable constructors of the rotary-drilled, gravel envelope wells considered this factor when designing the surface water control seal. To those not familiar with the gravel envelope well, probably the construction factor of most concern is the question of the efficiency of the surface seal. When properly installed, the control seal for this type of construction is more capable of positive confinement than the seal employed in any other method of drilling. The seal for a rotary drilled gravel envelope well is installed by reaming the test

bore to a diameter at least 10 in. greater than that of the contemplated completed well bore, to the depth of the formation which the test bore has shown to be favorable for a control casing foundation. The control casing, which is 6–8 in. smaller in diameter than the reamed bore, is then installed with the bottom securely seated in the impermeable formation decided upon as a foundation (Fig. 1). At least two small-diameter pipes are then inserted between the wall of the hole and the casing to within 1 ft of the bottom of the reamed bore. Cement is then introduced under pressure through the small-diameter pipes. These pipes are removed as the cement rises in the space between the control casing and the large-diameter bore. It may be noted that the volume of cement required is always in excess of the amount actually necessary to fill the space. It can be assumed, then, that the cement is actually penetrating the permeable formations to be sealed.

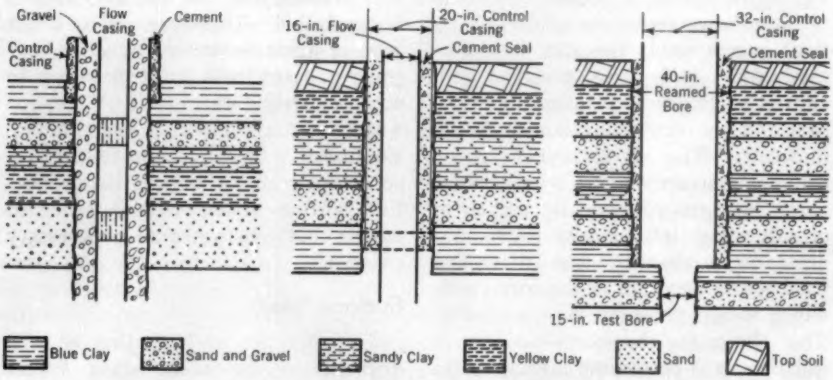

Fig. 1. Cross Section of Typical Gravel Envelope and Cable Tool Well Control Seals

Cross section at left is of gravel envelope well; that in the center, of a cable tool well control seal; and, at right, a gravel envelope well control seal.

Unless a test bore has been drilled before construction, it is impossible to determine by the cable tool method the thickness of the impermeable formation in which the control casing is to be set. Uncertainty about this dimension may result in seating the control casing only a small distance above the bottom of an impermeable formation depended upon as the foundation of the control seal. Agitation, during the drilling operation, may then cause the seal to break down, rendering the control casing and the seal ineffective. Because it is often essential to use a starter ring at the bottom of a cable tool control casing, the hole cut in the formation is a little larger than the diameter of the control casing (Fig. 1). This may allow percolation along the external wall of the control casing and around the starter ring. Although cement is placed between the flow casing and the internal wall of the control casing in the cable tool method of sealing, this cannot be accomplished

until the flow casing is in place. Therefore, the control casing must retain its position during the entire drilling operation in order to be efficient. It is possible, however, to install a seal by the cable tool method by introducing the cement between the casings and by retrieving the external control casing as the cement is being placed. This method is more efficient than that described above but it is practical only when the seal is not to be extended to a depth of more than one stratum. The retrieving of the casing is usually quite costly and sometimes impossible.

Casing Installation

When the control casing and seal have been installed by the rotary method the remaining portion of the well to be completed is reamed to the desired diameter of the finished well. This diameter, for proper construction, should be at least 14 in. greater than the diameter of the flow casing to be employed. It may vary, however, depending upon information obtained during the drilling of the test bore. When very fine sands have been encountered during the drilling of a test bore and there is a possibility that sand intrusion may be difficult to control, it is usually desirable to ream to a greater diameter that portion of the bore where the sand is encountered. When the entire bore has been reamed to the desired diameter the casing is installed. Centralizing spacers atttached to the casing at regular intervals insure an equal distribution of gravel around it. The casing used is machine perforated with openings of proper size and design depending upon the size of gravel to be used. Most casing suppliers are capable of furnishing perforations of any width from $\frac{3}{32}$ in. to $\frac{1}{2}$ in. These perforations are usually saw cut or milled approximately $2\frac{1}{2}$ in. in length. It is also possible to obtain a louvre type of perforation which is a hooded segment approximately $1\frac{1}{2}$ in. long and having a very small opening. This kind of perforation is assumed to restrict further the velocity of the water entering the well. Because the direction of percolation is usually unknown, the merits of this design are doubtful.

Perforations for a cable tool well are usually placed after the casing is in position in the well. Because the cable tool well does not normally depend upon the percolation of water for entry into the casing, the perforations must be placed as close as possible to the elevation at which water-bearing formations occur. In this kind of well, however, the mechanical limitations of the instrument used to perforate the casing are such that the design, placement, and size of the perforations may not be as exact as is often desired.

When casing is installed by the rotary method, select water-worn and washed gravel is placed between the reamed bore and the external wall of the well casing. The gravel is inserted in small quantities and, during its installation, fluid is circulated upward from the bottom of the well to insure a uniform envelope for the entire depth of the well. The elevation of the gravel is constantly ascertained during the installation so that any bridging which may occur can be promptly remedied. The amount of gravel installed normally exceeds by 10–25 per cent the amount necessary to fill the area between the reamed limit and the casing. It is assumed, therefore, that the unconsolidated material removed during drilling is replaced by the gravel. Gravel size is determined by the characteristics of

the materials extracted during the drilling of the test bore. The function of the gravel is retention of the diameter of the bore, decrease of the drawdown by the reduction of entrance friction, and prevention of caving around the casing which, in turn, eliminates the possibility of collapse as long as the gravel envelope moves to replace voids which may develop. When the well is completely filled with gravel, all excess drilling fluid is removed by circulating and washing with clean water from the bottom of the casing upward. A tight fitting swab is then oscillated opposite all perforated sections of casing further to insure a complete gravel envelope. This operation is of vital importance in the proper construction of a gravel envelope well and, in order to obtain the desired results, it must be thorough. "Mudded off," a term commonly used to describe a well which will not produce clear water in anticipated quantity, usually refers to a well in which the washing operation was not complete. A well property constructed and developed cannot and will not "mud off." This is borne out by the fact that improperly constructed wells will often increase their flows when agitated with detergents, dry ice, or wetting agents. These wells will always produce quantities of the original drilling fluid during and immediately following the agitation. It may be further noted that two wells with similar formation characteristics, the same elevation, in the same area, and of proper construction will always yield approximately the same quantity of water.

Well Development

A contract for a gravel envelope well should include specifications for correct development and testing. This phase of construction is generally accomplished by installing a deep-well, turbine type test pump with the pumping element set below the maximum probable pumping level and designed to deliver at least 30 per cent more volume than the anticipated requirements. The pump should be equipped with a variable-speed power supply, a restrictive valve, and a measuring device for both volume and pumping level. Well development should be done under the supervision of one thoroughly familiar with well construction. Developing should commence by pumping at a very low rate, increasing the flow gradually as the discharge of coarse material decreases. The primary purpose of well development is to cause the water-bearing formation to return as nearly as possible to the state existing before the disturbances caused by the drilling operation and to allow the gravel gradually to replace excavated material as the well positions itself. It is therefore not essential that a well pump a quantity of sand in order to develop properly. When the clear-water discharge is of sufficient quantity or the pumping level is becoming excessive the well should be surged or back-washed. Surging should be done in progressive steps with precautions taken to avoid excessive removal of material. When the well can be surged as often as will be ultimately required and yet produce clean water, development is completed. During final testing, the well should be pumped at regular intervals at rates of flow from the maximum intended yield to the minimum practical yield below the static water level. It should be allowed to discharge at each interval until the pumping level becomes stable. Information derived should, of course, be recorded and used as a basis

for the drawdown characteristic curve of the well. This curve should be utilized in designing the permanent pumping plant.

Reverse-Circulation Method

In many of the midwestern states, gravel envelope wells are now being successfully constructed by the reverse-circulation hydraulic-rotary method. This is a very modern method of rotary drilling which depends upon the velocity of fluids moving upward through the drill pipe for removal of the cuttings and material from the drilled hole. The drilling fluid is introduced by gravity into the bore hole and is extracted by means of a centrifugal pump attached to the top of the drill stem. Because the pump removes fluid from the drill stem more rapidly than water can be introduced, the solids are carried simultaneously with the fluids through the pump and discharged into the circulation reservoir. The viscosity of the drilling fluid is not of any particular importance in this process and commercial clays are not used unless it is absolutely essential to prevent water loss. This condition eliminates the washing process necessary in the normal hydraulic-rotary method of construction. Reverse-circulation drilling requires a large working area, for the reservoir should be of sufficient size to contain all the cuttings removed and the water for refilling the bored hole. Because it is not possible by this method to drill a small-diameter bore, a test bore must be drilled by other equipment before construction. The method is not adaptable at the present time in most of the far western states because of physical conditions in those areas. Present equipment cannot readily remove heavy clay formations and is not capable of drilling igneous formations. Because this drilling method requires much more water than the straight-circulation rotary method in which mud is used, unless productive wells or other water supplies are available it is practically impossible to transport sufficient water to the job site for drilling purposes. Until very recently, this type of equipment has been limited to drilling depths of approximately 400 ft. Manufacturers of reverse-circulation equipment, however, have utilized air induction to increase the velocity through the drill pipe, thereby allowing drilling to a much greater depth. As manufacturers improve their equipment reverse-circulation rotary drilling will become more popular because the method eliminates some of the costly phases of standard hydraulic-rotary drilling. Any improvement would, of course, necessitate a new method of drilling a test bore.

Redevelopment and Repair

A very important service rendered by well-drilling contractors is the redevelopment and repair of wells. Any person providing this service should be thoroughly familiar with the construction of wells and the influence of certain pumping conditions. There are many services and chemicals available today for well repair and redevelopment; among these are well photography, gamma logging, and directional service. The chemicals used are normally wetting agents, detergents, and acidifiers. These services and chemicals are all advantageous to the owner provided the person doing the repair or redevelopment is sufficiently experienced to utilize them properly. The service and repair measures are so varied that it would be impossible to

enumerate types and methods here. Well redevelopment should begin with a primary survey to determine the condition of the casing. The next step is the swabbing and cleaning of perforations which should be done with extreme caution—particularly in relatively old wells. The test pump is then installed and operated in the same manner as that described for the development and testing of a new well.

Summary

In the order of their importance, the advantages of a properly constructed gravel envelope well are:

1. The same equipment is used to drill a test bore—which will accurately log formations encountered—as is used to complete the well.

2. Abandonment of a well for any reason is possible at relatively low cost because no material is involved before the well potential is determined. Further, well depth and absolute cost are ascertained before the use of any materials.

3. More efficient sealing from surface contamination or intrusion is possible.

4. Large diameter bores are possible; this insures admittance into the well of water from all horizons—including sandy formations which cannot be developed by a cable tool well.

5. Casing with machine-cut, milled perforations designed to the well characteristics can be installed in the proper position as indicated in the test bore or electric log. This assures entrance of a maximum supply of water into the well and a minimum drawdown while the velocity is retarded in order to reduce sand intrusion.

6. Rotary drilling equipment is more adaptable to drilling all types of formations—particularly those which may cause the immovability of cable tool casing that necessitates reduction of pipe diameter.

Although a properly designed and constructed rotary-drilled gravel envelope well is the best medium for obtaining underground water, its efficiency is directly dependent on the competency of the well-drilling contractor performing the service.

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Water Well Construction in Formations Characteristic of the Southwest

Roscoe Moss Jr.

A paper presented on Oct. 31, 1957, at the California Section Meeting, San Jose, Calif., by Roscoe Moss Jr., Engr., Roscoe Moss Co., Los Angeles, Calif.

IN the Southwest, the task of providing water to a burgeoning industry and growing population is difficult and complex. Engineers, in designing new facilities to accommodate this ever increasing demand, are faced with a great number of problems. Perhaps the least understood of these problems is the proper design and construction of high-capacity water production wells. Suitable well casings and screens must be selected, and methods and specifications for drilling must be devised. These and other factors have to be carefully considered to achieve satisfactory results.

Basic concepts involved in water well construction by the cable tool and rotary methods are discussed in this article. Criteria for the selection of a particular method are considered—with emphasis on economic as well as performance factors.

Cable Tool Method

The cable tool or percussion method of drilling is applied to the construction of most high-capacity wells in the western part of the United States.

The bore hole is produced by the free fall of the bit (Fig. 1) suspended from the drilling machine on a wire line. Drilling motion is produced by the rapid raising and lowering of the tool. This motion must be kept in step with the fall of the tool and the natural frequency of the elastic system composed of the tool and the wire line. The performance of the cable tool bit depends upon the amount of kinetic energy it can deliver when striking the bottom of the hole. Factors that influence the drilling operation are: characteristics of the formation, frequency of motion, degree of line hitch or tension, tool weight, length of stroke, and techniques by which cuttings are suspended and removed.

The most efficient system employed in drilling unconsolidated formations is achieved with a combination of mud scow and hydraulic jacks. As shown in Fig. 2, when using the mud scow, cuttings are produced on the downstroke and removed on the upstroke. In actual practice, unconsolidated sands and gravels are removed virtually intact by the pressure differential created by the upward stroke of the scow. A system of hydraulic jacks (Fig. 3), which maintains almost constant pressure on the casing during drilling operations, keeps the casing shoe more or less aligned with the drilling. The bore hole is held open in this manner by the casing as drilling progresses.

For drilling water wells in alluvial formations, the system described above is the one most commonly used in some areas of the Southwest. It has certain advantages over drilling with standard tools: The rate of penetration is two to four times higher, a more accurate well log is achieved (because cuttings are removed relatively intact), the action of the scow tends to develop the well as it is being drilled, the solid bit pulverizes the formation and tends to drive cuttings back into the walls of the hole, and the use of drilling mud for the suspension of cuttings is not required.

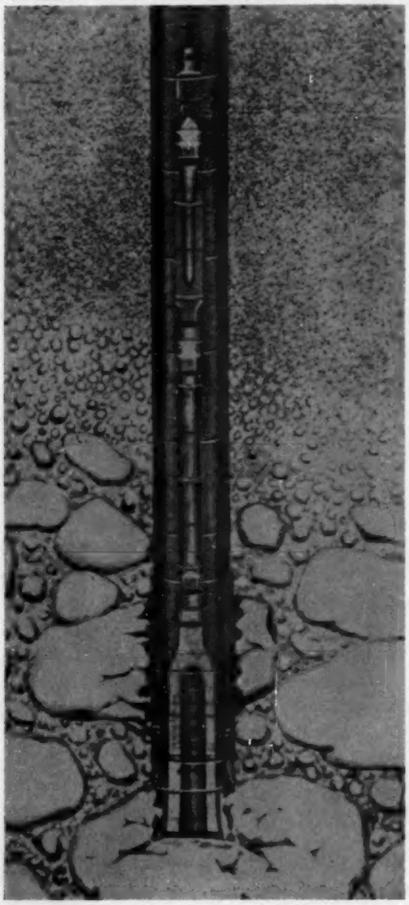

Fig. 1. Bit Used in Cable Tool Method of Drilling

Bore hole is produced by free fall of the bit.

Casing

Cable tool wells are cased with either single- or double-wall casing, depending upon requirements. Use of single-wall casing is generally restricted to shallow wells of 16-in. diameter or less or where an open hole can be drilled before installation of casing. Double well casing has proved to be more satisfactory when heavy jacking pressures or driving forces are required during the drilling process.

Figure 4 illustrates the manner in which maximum joint strength is provided with double casing. It is evident that casing made up in this manner can remain intact even with failure of a field weld. This margin of safety does not exist when operating with single butt-welded casing, and failure of a weld frequently means loss of the well. In addition, double well casing is fabricated from a high-tensile corrosion-resistant steel in order that it may satisfactorily withstand the punishment it receives under drilling conditions.

Perforations

The Mills knife and hydraulic louver-type perforators (Fig. 5) are types most commonly used in the western states. The Mills knife is a mechanically operated perforator which produces a vertical opening approxi-

mately ½ in. wide and 5 in. long (Fig. 6).

The presence in many areas of highly productive aquifers composed of fine gravels and coarse sands requires a perforation which can more effectively control the pumping of fine ma-

2. The hydraulically operated perforator permits a more precise control of aperture size.

3. The louver-shaped opening achieves much greater stabilization with fine materials. From Fig. 8 it is apparent that, with a vertical open-

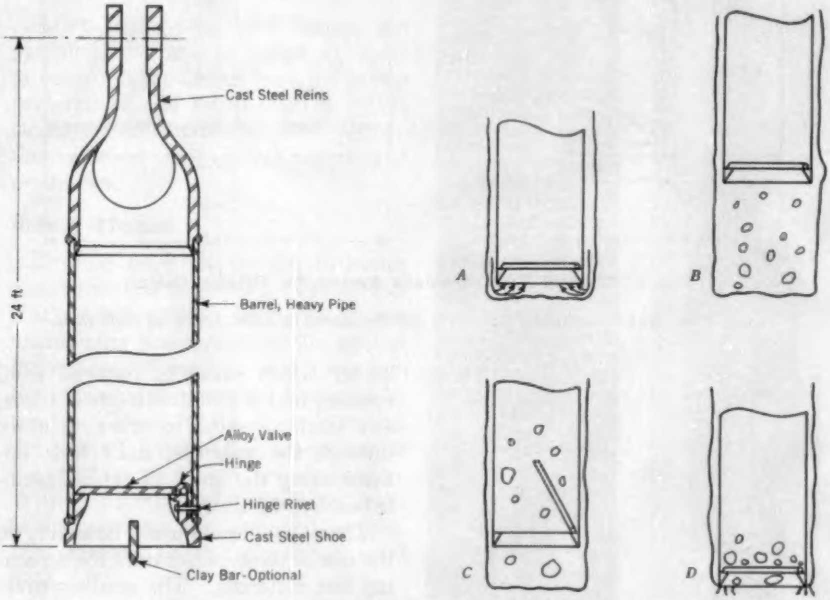

Fig. 2. Mud Scow Construction and Action

Portion of diagram labeled A *shows scow as it begins to rise from bottom of bore hole. Washing action (shown by arrows) lifts cuttings. In* B, *top of stroke has been reached and cuttings are suspended.* C *shows scow falling, with valve open and cuttings flowing into scow. In* D, *scow has struck bottom. Valve has closed, trapping cuttings as shoe breaks formation below.*

terials. The horizontal-louver perforation (Fig. 7) is the most effective type of opening for these conditions. This opening has these advantages over the Mills cut:

1. Superior physical characteristics are imparted to the casing.

ing, a large number of small particles must bridge together in the vertical (critical) plane, whereas with the horizontal opening only a relatively few particles are required for stability (Fig. 9). Another advantage is derived from the overhanging lip of the

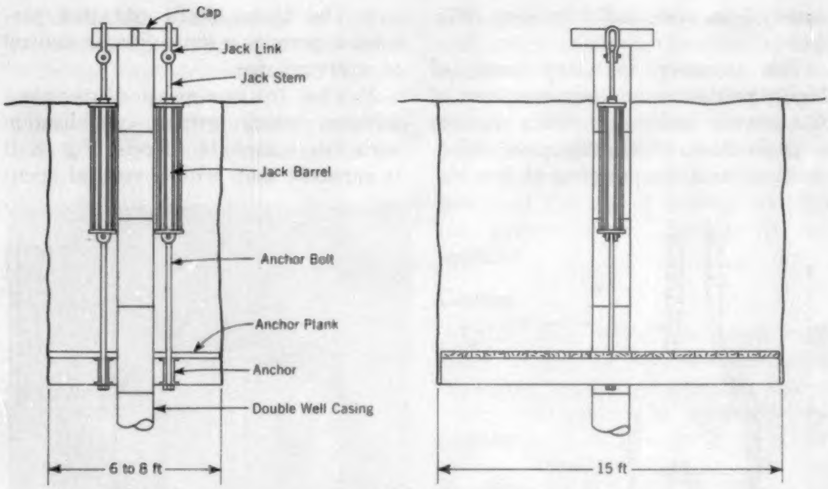

Fig. 3. Typical Hydraulic-Jack System for Driving Casing

Two 8-in. jacks operating at 2,000 psi produced a total force of 100 tons.

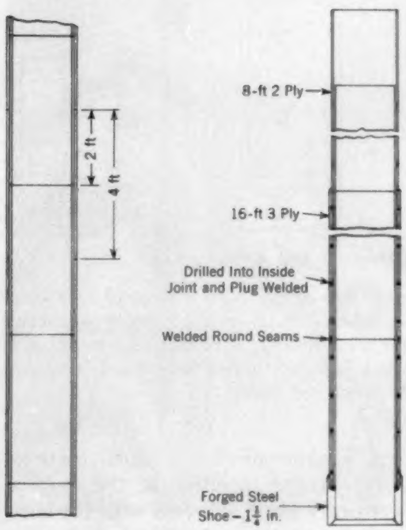

Fig. 4. Diagram of Double Well Casing

Portion at left shows casing installed; that at right shows starter section.

louver which prevents material from running into the well. In other words, any sands or silts, in order to move through the aperture, must flow upward along the angle of repose established by the louver.

There are limitations, however, in the use of these perforators for screening fine materials. The smallest practical openings are $\frac{1}{8}$–$\frac{5}{32}$ in. and fine sands and silt which are not intermingled with coarser particles must be stabilized with an artificial gravel pack.

Selective Perforation

As previously discussed, one of the principal advantages derived from drilling with a mud scow is the high accuracy achieved in the well log. This permits accurate adaptation of perforation to well defined aquifers. Because the size and gradation of material in a particular zone can be obtained from the cuttings, the width of

opening can be sized to permit maximum flow of water commensurate with formation stabilization. Total well production is not impaired since most of the water comes from the more permeable aquifers; muddy or silty zones can therefore be avoided.

Preliminary Development

After perforating, and before test pumping, the well is bailed in order to remove fine material from the casing perforations and the well itself. This cleans the face of the aquifers, permitting efficient well development and production.

Rotary Method

Drilling of wells by the hydraulic rotary method requires a cutting tool (bit), rotation of the tool, a means for maintaining pressure of the bit against the material being cut, and a medium for removing the material displaced by the bit. These four factors determine the rate of longitudinal movement of the cutting tool into the formation. With this method of drilling, the walls of the bore hole are kept open by pressure created by the circulating mud fluid.

Procedure

The construction of gravel envelope wells has become fairly standardized in recent years. The basic procedure is as follows:

1. A pilot bore 12–15 in. in diameter is drilled first. This test hole also serves as a means of securing information required for establishing the casing program. Often, the completed bore is as large as 28 in. in diameter and cannot be handled in one pass.

2. The pilot hole is then opened out for installation of the conductor casing. This conductor bore should be 4–6 in. larger than the diameter of the conductor. It is preferable to land the surface casing in clay or other impermeable strata in order to obtain maximum value from any sealing operations. This also prevents loose material from sloughing in around the shoe.

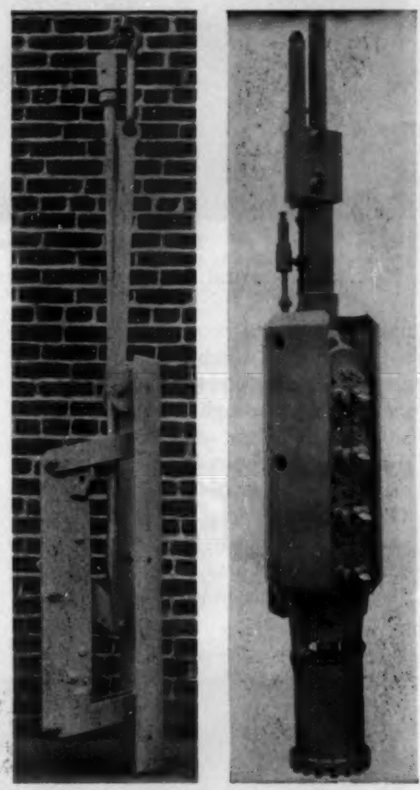

Fig. 5. Perforators in Common Use in the West

At left is shown the Mills knife and, at right, a hydraulic louver-type perforator.

3. Two methods of grouting surface casings are generally employed. The

Fig. 6. Openings Produced by Mills Knife

Vertical slots are approximately ½ in. wide and 5 in. long.

most economical procedure consists of spudding the conductor casing into clay strata and pumping a suitable cement slurry through tubing set in the annulus. Where a more complete grouting is required, the Haliburton method is most commonly employed. With this procedure, the casing is suspended approximately 2 ft above the bottom of the hole. The conductor is then filled with fluid and a pressure cap is set in the top (Fig. 10). A neat slurry weighing 115 lb/cu ft is pumped through tubing to the bottom of the hole and is forced up the annulus to the surface. This method not only provides for a more positive sealing off of surface waters, but also prevents possible casing collapse from perched mud or water.

4. After the slurry is allowed to set for at least 12 hr, the bottom plug

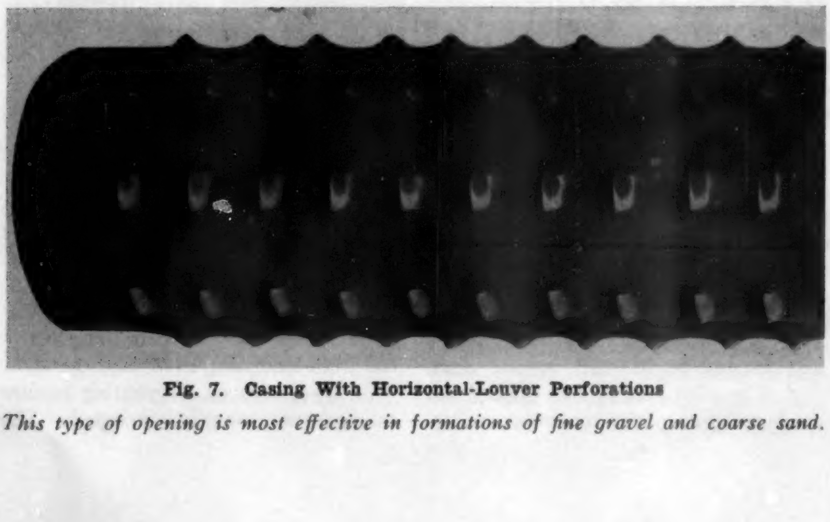

Fig. 7. Casing With Horizontal-Louver Perforations

This type of opening is most effective in formations of fine gravel and coarse sand.

is drilled out. The pilot bore is then opened out to a diameter 6 in. greater than that of the well casing to form the well casing bore.

5. Well casing is then placed. The diameter of the well casing depends upon the diameter of the pump bowls and column pipe to be installed. Screen diameter will be a function of the anticipated well production.

6. Gravel is then placed in the annulus.

7. The completed well is swabbed in preparation for development and test pumping.

Proper Construction

It would appear from the abovementioned procedures that rotary-drilled gravel envelope wells provide a solution for all well problems. An artificial gravel pack, theoretically, should allow all aquifers to produce at maximum capacity without excessive production of sand. In actual practice, however, this does not prove to be so. A great many gravel-packed wells drilled in marginal areas produce excessive quantities of sand. Actually, some are inferior in this respect to cable tool wells drilled in the same area. Such a situation can be avoided by taking the following precautions.

Assuming that proper well screens and filter materials are installed, the primary objective during the construction operation is to ensure complete enclosure of the well screen with filter materials. If the gravel envelope is not continuous at all points behind the wall screen, proper formation stability cannot be achieved. It is, therefore, necessary to consider carefully the following points if a perfect gravel filter is to be established around the screen casing.

A secure foundation is provided by proper installation of surface casing.

The bore must be straight and plumb to insure correct installation of well casing, which must be suspended in tension from the conductor and suitably guided in order that it be centered at all points in the bore. If the casing is allowed to rest on the bottom, the resultant buckling will cause it to make contact with the walls of the bore hole.

A finely graded gravel pack is required to control the pumping of fine sands and silts properly. The gradation should fall roughly within the following limits:

Screen or Sieve Designation or Size*	Amount Passing *per cent*
$\frac{3}{8}$ in.	100
3	90–100
4	65–80
8	10–20
16	1.0–0.5
30	0

* ASA designations.

Generally speaking, most gravel companies produce a reasonably well rounded material with gradation approximating the above. Under no circumstances should crushed material be installed in a well. There have been instances where the installation of crushed rock has stopped water production.

The most commonly employed gravel installation system is shown in Fig. 11. Two swabs mounted on the drill stem cause the circulating fluid to flow up the annulus. Water is introduced into the system, and mud weight in the annulus is reduced to at least 68 lb/cu ft. Gravel can be introduced against the circulating stream at the surface or pumped through tubing into position at the bottom of the hole.

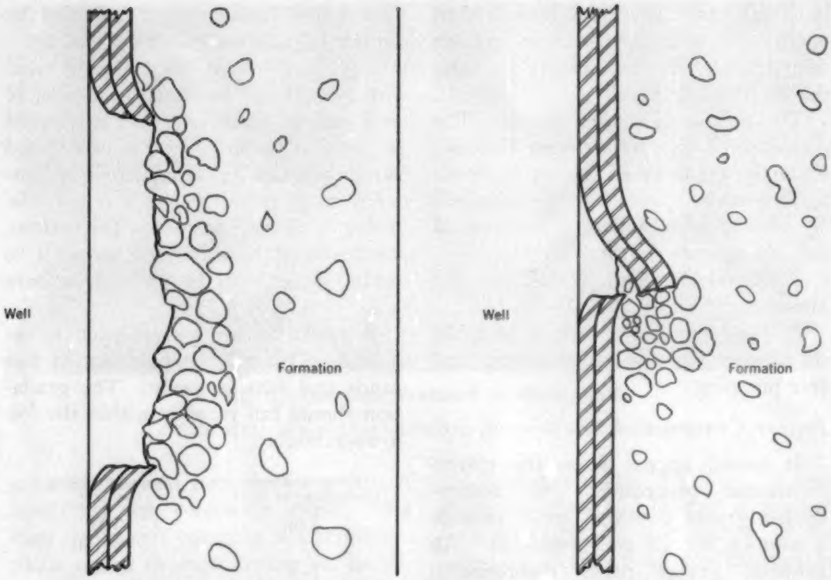

Fig. 8. Gravel Screens Around Typical Perforations

Section at left is of vertical perforation; that at right, of horizontal louver.

Fig. 9. Actual Bridging of Horizontal-Louver Perforations by Gravel

Relatively few particles are required for stability.

If blank casing extends to depths greater than 400–500 ft, gravel should be pumped in through tubing. Consolidating the gravel envelope becomes more difficult when long sections of blank casing are installed. Under normal conditions, however, satisfactory results have been consistently achieved by careful installation of gravel from the surface. The circulating stream serves to remove any fine materials from the gravel and prevent possible bridging.

Discussion of the various types of well screens requires, first, the determination of criteria for establishing proper zones of perforation. One school of thought contends that perforations should be located only at the water-bearing strata; this is selective perforation. In order to achieve it, the well log should be comparatively accurate. Usually, rotary well logs are not this reliable because of: [1] delay in the return of cuttings to the surface, [2] variation in the rates of cutting return—depending on particle size and shape, [3] sloughing of formation into the circulating stream, and [4] the pulverizing action of the drill bit. Electric logs have been utilized as an aid in determining the boundaries of production zones but results have been marginal because of improper interpretation and the many parameters which determine potential and resistivity readings.

Even if all production zones could be accurately located, selective perforating is still undesirable because gravel has a marked tendency to bridge just above the top of the stream. This leaves a cavity in the upper section of the screen, permitting uncontrolled flow of fine materials into the well. The gravel envelope can be consolidated by swabbing, but control of gravel movement behind blank casing is difficult to achieve. If alternating sections of blank and screen casing are installed, the difficulties in maintaining necessary control of the gravel filter are compounded. The advantages achieved in employing a continuous screen with maximum control over gravel movement and production from all zones more than offset any savings realized from reduced screen length.

Because a finely graded gravel envelope is required for obstruction of sands and silts, it becomes imperative to design a screen which will establish proper stabilization of the gravel as well as permit maximum flow of water. Experience has shown that a $\frac{1}{8}$–$\frac{5}{32}$-in. opening is a practical minimum size. Smaller openings have been attempted but many have sealed off as a result of corrosion or the wedging of fine particles in the opening. An opening of the above size will permit the passage of approximately 70 per cent of the gravel screen.

It is evident then that the shape and orientation of the perforation is extremely important. As previously noted, a vertical slot cannot stabilize fine particles. A horizontal slot will establish the required stability but has one drawback in that the finer particles have a tendency to bridge and clog in the slotted opening. The louver-shaped or shutter screen perforation presents an orifice that has nonparallel surfaces. This, in large measure, solves the plugging problem, and has the added advantage of being 20–30 per cent stronger in radial compression than the slotted screen. The downward facing aperture provides for maximum control of the gravel envelope.

Reasonable control of drilling-mud weight, viscosity, and filter loss should be exercised during operations in order to prevent excessive wall cake

and fluid loss into the formations. All drilling mud must be removed from the annulus before gravel installation in order to prevent blocking of the aquifers.

After the gravel envelope has been placed, the well must be thoroughly washed and swabbed with the rotary

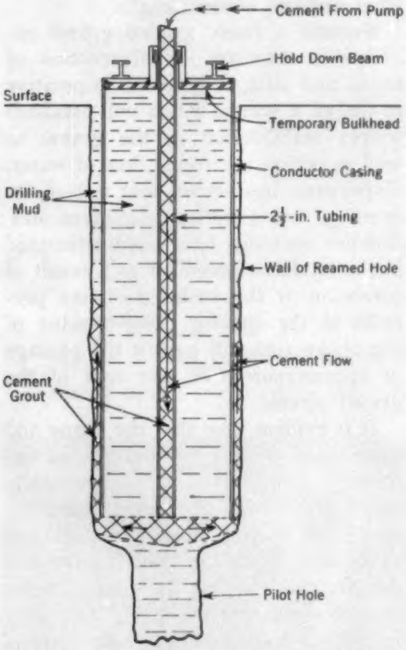

Fig. 10. Cementing of Conductor Casing

Direction of flow of cement grout (cross hatching) is shown by arrows.

rig. Water should be added continuously to the circulating system in order that mud and fine materials which are swabbed into the system can be disposed of.

Because of its operating characteristics, a rotary rig cannot swab as effectively as a cable tool rig. With proper operation a cable tool rig can locate tight zones or cavities and, by giving the swab a reciprocating motion, can bring in material and move or consolidate the gravel. It has become standard practice in some areas to perform initial development work on all rotary-drilled wells with a cable tool rig before installation of the test pump. In these areas, if this is not done, the well cannot be successfully brought in.

Development

Development work performed with the turbine pump is as important to final well performance as the drilling of the well itself. By and large, because the drilling of a cable tool well is performed without mud and the aquifers are selectively perforated, there are fewer problems involved in developing a well of this type. As developing proceeds, a natural gravel pack is formed around each perforation by the removal of fine materials near the face of the aquifer.

Great care must be exercised in the development of a gravel envelope well. Mud and fine particles must be removed from the face of the aquifer. At the same time, excessive material must not be pumped, for this will produce cavities with resultant discontinuity of the gravel envelope.

In fact, few rules can be written concerning procedures for development and test pumping. The pump should have greater capacity than the expected working production so that the well can be conservatively operated at less than its developed capacity. The pumping should be started at a low rate and each step in the development

carefully observed. Because of the presence of mud and fine particles the well, initially, will pump a relatively small quantity of water. As the water clears, backwashing and surging is commenced. This loosens and removes the materials which are blocking the flow of water and the specific ca-

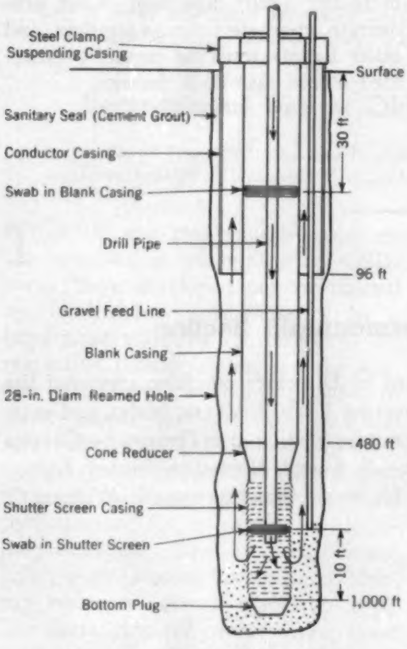

Fig. 11. Placement of Gravel

Arrows indicate direction of flow of water.

pacity increases. As this operation is repeated, the time required for the water to clear will become shorter Ideally, when development is complete, the well should be capable of being surged without subsequent production of objectionable quantities of sand and silt. When testing for maximum yield it is imperative that sand production be checked with a reliable measuring device, because, with most wells, beyond a given capacity, the flow of sand rises rapidly. This is due to the fact that excessive pressures or velocities produced in the aquifer can lead to small movements of fine materials which cause localized breakdowns in the filter screens. If final production is maintained below the velocity which produces this movement, the chances of developing any operating difficulties are slight.

Conclusions

One of the primary considerations when selecting the method of drilling to be employed on a given well is construction cost. All other factors being equal, the cable tool method is more economical to depths of approximately 1,500 ft. This is particularly true with large-diameter bores where difficult drilling conditions are encountered. With wells to depths of 2,000 ft and greater, where formations encountered consist mainly of fine gravels, sands, and clay, the higher penetration rates achieved by the rotary machine tend to offset its higher operating cost. Many relatively inexpensive rotary wells are drilled, of course. There, however, costs are reduced through the installation of lightweight and less durable casings and the employment of questionable construction practices. Such economies frequently result in considerably reduced well life.

Generally, cable tool methods of well construction continue to predominate in areas where aquifers are coarse and fairly well defined. Recent production comparison tests between gravel en-

velope and nongravel envelope wells run in an area of this type indicated no difference in specific capacity between wells. In fact, a slightly higher yield was obtained from one of the nongravel envelope wells. Sand production was approximately the same for all.

There are some areas where, regardless of cost, gravel envelope wells must be constructed. Such an area would be one containing many aquifers composed of fine sands and silts which cannot be naturally screened off with a standard perforation screening. An artificial gravel pack is required in such circumstances to permit proper development and control of the producing lenses.

It is apparent, then, that careful consideration must be given to many factors when choosing the proper method of drilling a particular well. Cost, production, characteristics of aquifers, and other factors must be carefully evaluated before making a decision.

Organization of Intermountain Section

On Apr. 20, 1958, the AWWA Board of Directors officially approved the organization of a new AWWA section covering Utah, southern Idaho, and eastern Nevada. Officers of the new Intermountain Section are: chairman—Charles W. Wilson, Salt Lake City; vice-chairman—R. Joseph Huckabee, Burley, Idaho; director—W. Franklin Richards, Ogden, Utah; secretary-treasurer—William C. Hague, Salt Lake City.

Pollution Control in Southwestern Reservoirs and Watersheds

Panel Discussion

A panel discussion presented on Oct. 15, 1957, at the Southwest Section Meeting, Oklahoma City, Okla.

Recreational Use in Oklahoma—*Loyd F. Pummill*

A paper presented by Loyd F. Pummill, Asst. State San. Engr., State Health Dept., Oklahoma City, Okla.

THERE are two general types of impounding reservoirs in Oklahoma: those developed and constructed by municipalities and financed by a bond issue voted by the people of the respective municipalities, for the specific purpose of providing a source of water supply for domestic use; and reservoirs developed and constructed by agencies of the state or federal government, with or without municipal participation, for a variety of multipurpose uses. The Texoma, Grand Lake, Fort Gibson, Canton, and Murray reservoirs are of the latter type. The supplying of water from these multipurpose reservoirs for domestic use may or may not be one of the immediately intended usages.

The recreational uses and benefits to be derived from them are considered and included in the justification for the construction of the multipurpose reservoir. This discussion will, therefore, be limited primarily to the control of pollution—particularly from recreational use—in water supply reservoirs constructed by municipalities.

State Legislation

Oklahoma laws governing public water supplies authorize cities and towns to adopt water district ordinances to protect supply reservoirs from unnecessary contamination. Title 11, Sec. 298, O.S. 1951, contains the following in regard to the establishment of water districts:

> Any city or town in this state securing its water supply from a reservoir located outside its corporate limits, shall have the power and is hereby authorized to designate, by ordinance, through its mayor and council or other law-making body, a district to be known as a water district; said water district to be designated by metes and bounds, and to embrace any lands directly or indirectly flowing or shedding water into any such stream or reservoir, in the discretion of said city or town, and said city or town . . . shall have the power and is hereby authorized to enforce any rules and regulations made by the state commissioner of health, the county superintendent of public health, or the city superintendent of public health, for the protection of any such water supply.

Oklahoma statutes also place certain mandatory restrictions on reservoir marginal land owned by municipalities. Under Title 11, Sec. 293, O.S. 1951, municipalities are empowered to purchase or condemn lands for a reservoir, and also lands adjacent thereto and within 660 ft of the margin of the reservoir at maximum high water. Municipalities are further authorized to acquire any lands which their governing body determines, by resolution, to be necessary to protect any reservoir already constructed, proposed, or to be enlarged. This same statute imposes the following limitation on the use of marginal land:

> That the property and land acquired as herein provided, and all lands previously acquired and hereafter acquired insofar as the same are within 660 ft of the margin of such reservoir at maximum high water, except such or any part of such lands the natural drainage of which is not into such reservoir, shall not be used by such municipal corporation, its lessees or assigns, or other persons or corporations, for any purpose other than the protection of such reservoir, and the waters thereof, from contamination and pollution, and no structure shall be placed thereon by any such municipality, individual, or corporation, except such as are necessary in the furtherance of the protection of such reservoir from contamination or pollution and in the use of such water.

Whether or not a municipal water supply reservoir shall be used for recreational purposes, and if so to what extent and under what circumstances, is decided by the municipality concerned. The state department of health is charged (Title 63, Sec. 613, O.S. 1951) with insuring that the water delivered to the consumer is safe. The department is authorized, by state statute, to order such changes in the source of the water supply, or in the manner of storage or treatment of the supply before delivery to consumers, or both, as may be necessary to safeguard the public health.

Reservoir Recreational Use

Fishing is permitted in all Oklahoma municipal water supply reservoirs, as far as the author is aware. As a result, considerable controversy could arise as to whether the recreational advantages outweigh the possible damage to public health, and whether such use opens the door for other recreational uses, which may have more serious public health implications. Fishing, however, has been permitted for a good many years; it would, in all likelihood, require a serious outbreak of a waterborne disease directly traceable to contamination by fishermen before any consideration would be given to discontinuation of the practice.

During the past few years municipal officials in Oklahoma cities obtaining their water supply from impounded reservoirs have been subjected to considerable pressure from water sports enthusiasts to open the reservoirs to water skiing. In at least one of these cities the council chamber was filled to capacity by the proponents of water skiing while the subject was under consideration. In addition to this representation, the group was armed with a petition, signed by the medical practitioners of the community, requesting that favorable consideration be given such recreational use. Apparently these two groups had much more confidence in the adequacy of the water treatment facilities and the ability of operating personnel to maintain a safe water supply than had either the water supply management or the public

health officials responsible for the safety of the supply.

The proponents of water skiing on reservoirs have advanced the following arguments:

1. Opening the reservoirs to water skiing will make a wholesome, healthful water sport available to a number of people without the necessity of their driving, in some instances, from 75 to 100 miles to one of the multipurpose reservoirs located in the state.

2. The bodily contact of skiers with the water and the waste disposal problems created by attendant crowds in the reservoir area will not contribute as great an amount of pollution to the water supply as that which exists in some municipal raw-water sources, particularly rivers or streams which receive sewage from upstream cities and towns.

3. The water treatment facilities in existence are adequate to render and maintain a safe supply of water to the consumer at all times, even if some degree of pollution, containing the causative organisms of waterborne diseases, is introduced into the water.

4. The bodily contact with the water supply and the waste disposal from attendant crowds would not create any greater public health hazard than the practice—common in many sections of the state—of using lands adjacent to water supply reservoirs for the grazing of cattle.

Disadvantages

Modern public health departments recognize, in general, their responsibility for promoting the total health of the public, and are aware of the benefit to be derived from wholesome recreation. It is believed, however, that most public health officials would question to some degree the validity of the arguments presented by the proponents of water skiing on municipal reservoirs.

It is quite true that opening of municipal water supply reservoirs to such recreational use would in many instances lessen the amount of driving that is now necessary to participate in the sport at one of the multipurpose reservoirs. It is agreed that the sport should be considered a wholesome recreational activity. It is questionable, however, whether those participating in the activity would represent a very large percentage of the total water users, or of those who made possible the construction of the reservoir through bonded indebtedness and tax support.

The argument that additional pollution resulting from increased recreational use will not create as much of a pollution load as that which exists in raw water from rivers or streams does not offer much in the way of an inducement. Experience indicates that those municipalities using a supply source of poor-quality water do so, as a rule, from necessity and not from choice. The use of such water makes higher treatment costs necessary, in order to insure the greatest degree of protection possible under the circumstances. Experience will also show that cities have continued to abandon sources of heavily polluted or poor-quality water in favor of better sources whenever the opportunity became available.

The theory that complete water treatment as practiced in the conventional water treatment plant is infallible in preventing the transmission of waterborne diseases is certainly subject to question. To accept it would mean that equipment is not subject to mechanical failure, or that man never makes mistakes. It is an undoubted fact that adequate conventional water

treatment facilities, not loaded too heavily and properly operated, will produce a safe water as far as waterborne transmission of typhoid or bacterial enteric disease are concerned. There is considerable doubt, however, as to the effectiveness of the conventional water treatment plant in rendering the water safe with respect to the viral diseases that may be waterborne. The lack of information in regard to certain of the viruses, such as the echo (enteric cytopathic human orphan) types, and the extent to which some of the viral diseases may be waterborne further increases the complexity of the problem.

Ordinarily waterborne diseases are thought of as those diseases in which the causative organism is contained in the fecal discharges. When recreational use of reservoirs is increased to permit bodily contact with the water, however, the possibility is introduced that other diseases not normally considered waterborne may become a factor.

If, in this problem of water supply reservoir sanitation, public health considerations are based solely on the prevention of disease transmission, the use of lands adjacent to impounding reservoirs for the grazing of cattle is of little significance. Relatively few of the infections of the lower animals are thus transmissible to man. The problem of eliminating these infections does not compare in importance to the prevention of contamination by human waste.

If one discounts entirely the possibility of transmitting disease in its entirety through pollution of supply reservoirs by increased recreational use, the question must be answered whether all water users will agree to such additional uses from a psychological standpoint. Public health officials have used the slogan "Swim in Drinking Water" for many years in swimming pool sanitation programs. The question arises, if sports such as water skiing and swimming are permitted in water supply reservoirs: "Is the public willing to drink its swimming water?"

The safest water, milk, or food supply is that to which the greatest degree of practical protection from contamination has been given. When milk is prepared for public consumption, efforts are expended to produce and handle the raw-milk supply to provide the safest possible source, with pasteurization added as a final safeguard. In food sanitation, foods adulterated with filth or insect larvae, or contaminated in other ways, are removed from public channels; in meat inspection programs, diseased animals and cancerous animal tissue are not approved for use; yet it would be a simple matter to process these products in such a manner as to render them safe for human consumption.

Water is becoming more and more of a scarce commodity each year. This is gradually resulting in the acknowledgment by official agencies of the desirability of obtaining full value from all water resources. Where recreational uses of municipal water supply reservoirs are under consideration, decisions regarding what uses can be permitted must be made on a case by case basis, in the light of the relative benefits and hazards associated with a specific use, rather than by basing a decision on the uses which some other municipality has decided to permit. Such decisions should be made only on the basis of: [1] a complete knowledge of the hazards associated with the spe-

cific use, [2] how the hazard can be minimized, [3] the willingness of the taxpayer to bear the expense involved in providing such controls, and [4] additional treatment facilities and operational needs as each circumstance may dictate to provide the greatest degree of protection to the water user.

—Control and Protection in Arkansas—*Glen T. Kellogg*—

A paper presented by Glen T. Kellogg, Chief San. Engr., State Health Dept., Little Rock, Ark.

Almost all health departments concern themselves, basically, with two aspects of the pollution control of water supply reservoirs: preventing the contamination of the raw-water supply, and protecting the potable-water reservoirs.

Raw-Water Supply

The first concern of the health department is the protection of the raw-water supply. Certain rules and regulations concerning bacteriological quality have been established. The Arkansas Health Department uses the MPN method, and directs that the count shall not exceed an average of 5,000 per 100 ml, 5,000 in more than 20 per cent of the samples in any month, or 20,000 in more than 5 per cent of such samples.

From a public health standpoint, the desirability of municipal ownership or control of the entire watershed is recognized, but it is not always feasible. The amount and degree of ownership and control must be determined by the circumstances. The public health department recognizes that, while protection of the public health is paramount, rules and regulations are only enforceable as long as they are reasonable. In Arkansas natural pollution, silting, and other factors vary from watershed to watershed, and this variation must enter into the decisions of the state board of health. Thus, each case is decided upon its individual merits.

The state of Arkansas also requires that: [1] intake structures be located above sewer outlets, or other sources of contamination; and [2] the municipality own and maintain effective control of all property within an area 300 ft from the lake or impounded shoreline at spillway elevation.

With these requirements, adverse establishments or activities can be effectively controlled so as to prevent pollution or contamination of the water supply. The municipality or the private utility owner is responsible for compliance with the regulations.

Because the municipality owns the entire shoreline, enforcement is a simple matter of preventing trespassing, and if wastes which are potentially hazardous to the water supply are entering this 300-ft strip, the city may act to prevent this by injunction or other legal procedures. Similarly, the municipality, as it owns the entire shoreline, is in a much better position to say what may or may not be built on its property.

Concerning recreational use, the Arkansas Public Health Department believes it has taken an honest, and perhaps a liberal, attitude by permitting controlled recreation. Limited fishing and boating may be permitted, but no other recreation—such as swimming

or water skiing—during which the body is immersed, or in which the water supply might become contaminated and thus constitute a potential hazard to public health. Municipalities also can regulate the number of boats permitted on the lake.

Reservoirs

The second basic aspect of pollution control is the protection of potable-water reservoirs from contamination. The location chosen must be safe from contamination by surface drainage, sewers, privies, and septic-tank tile fields. The design of water stops, overflows, vents, covers, drains, and manholes must be supervised, as they are points of entry for possible contamination. Rules and regulations are designed, therefore, to prevent contamination before it occurs. How well the Arkansas Public Health Department has done its work is reflected in statistics which show that no major disease outbreak has been attributed to a public water supply in Arkansas in more than two decades.

—Legislation and Practice in Texas—*Henry L. Dabney*—

A paper presented by Henry L. Dabney, Chief Engr., Water Supply Section, State Health Dept., Austin, Tex.

The citizens of Texas in 1917 expressed their desire to secure proper watershed protection and management when they voted favorably on an amendment to the state constitution. This amendment covered the conservation and development of all natural resources. The preservation and conservation of these resources were declared public rights and duties, and the state legislature was authorized to pass such laws as were deemed appropriate to secure the desired objectives. In addition to this, the amendment, codified in Article 16, Sec. 59 (a) and (b) of the constitution of Texas, stated that:

> There may be created within the state of Texas, or the state may be divided into, such number of conservation and reclamation districts as may be determined to be essential to the accomplishment of the purposes of this amendment to the constitution, which districts shall be governmental agencies and bodies politic and corporate with such powers of government and with the authority to exercise such rights, privileges, and functions concerning the subject matter of this amendment as may be conferred by law.

In order to summarize briefly the specific state statutes which have been enacted by the legislature since passage of the amendment, the author obtained assistance and counsel from William H. Bell, legal consultant to the Texas Department of Health. Briefly, the statutes prescribe that home rule cities in Texas have the power to prohibit the pollution of any stream, drain, or tributaries which may constitute their source of water supply, and to provide for the protection of the supply by policing. Cities incorporated under general law are given the power to abate all nuisances of any description which are, or may become, injurious to the public health. There appears to be no doubt that cities can take legal steps to alleviate a pollutional condition, on the grounds that such a function is an inherent power of the governing body, designed to protect the health and well-

being of the people. Water districts and river authorities are also charged with the responsibility of preserving the public waters of Texas. They have the power to protect, preserve, and restore the purity and the sanitary condition of public water. They are specifically empowered to institute and maintain any suit or suits to protect the water supply and to prevent any interference with it. Rules and regulations for preserving the sanitary condition of all water controlled by the district can be promulgated, penalties for violation can be prescribed, and peace officers can be employed to enforce the rules and regulations. The Texas Department of Health, the State Board of Water Engineers, the Game and Fish Commission, the Oil and Gas Division of the Texas Railroad Commission, and the attorney general's department have also been charged by the statutes with responsibility for keeping streams and reservoirs free from pollution. The state of Texas should be made a party to any suit which might be brought by cities, water districts, or river authorities to allow it to protect what interest it might have.

These statements substantiate the fact that legal facilities are available to the state's various political subdivisions, and that pollution of surface waters can be controlled and abated through action initiated by them, with state cooperation. It should be emphasized that the abatement of pollution is the responsibility of municipalities, water districts, and river authorities, as well as of the state, and especially of those in areas contributing to the pollution of surface waters.

Policies and Practices

In view of the public health aspects of pollution, a review of the policies and recommended practices for reservoir sanitation might be presented to correlate the Texas program with programs being carried out by the state departments of health of Oklahoma, Arkansas, and Louisiana. The state statutes of Texas prescribe the general plan of approaching pollution control and abatement at the lowest echelon of government, but they do not establish specifically the pattern of reservoir development to reach or maintain desired sanitary standards of impounded water quality. Texas municipalities, water districts, river authorities, and other agencies must therefore depend upon the state board of health to adopt rules and regulations covering the sanitation of watersheds and the extent of recreational activity which may be permitted at public water supply reservoirs without threatening the sanitary quality of the raw water intended for municipal, domestic, or allied uses. Current Texas policies, as adopted by the board of health on Sep. 10, 1956, are outlined:

Watersheds. It is desirable that watershed areas either be virgin territory, or else be utilized preferably for grazing rather than for cultivation. All habitations on the watershed must possess satisfactory sewage disposal facilities, such as an approved type of septic tank and drain field, or pit toilet, located at least 75 ft from the lake water surface at the spillway elevation of the lake. No large stock pens or labor camps (oilfield, construction, or lumber) should exist within 20 mi of the raw-water intake works. It is also particularly desirable that there be no large centers of population, industries, railroads or highways located in the watershed within 20 mi of the watershed. Should such populated areas, industries, or transportation facilities

exist, however, all their liquid or solid wastes must be disposed of in conformity with stream pollution and water safety statutes.

It is advisable to make bacteriological, biological, limnological, and rheological investigations of the proposed source of raw-water supply and its tributary streams to determine the degree of pollution from all sources within the watershed and the possibility of the occurrence of taste and odor problems or the clogging of filters by algae. Where surface water reserves, subject to continuous contamination by municipal and industrial wastes, are contemplated for development as sources of public water systems, the effects of contamination must be determined by sanitary surveys and laboratory procedures.

Intake works. A restricted zone of ½-mi radius upstream from the raw-water intake works should be established, and all recreational activities (such as fishing, boating, swimming, or water skiing) and trespassing prohibited in this area. The restricted zone should be designated with markers or buoys. Where the ½-mi radius is not possible, a zone as large as possible should be set up, and posted and defined adequately, to minimize the creation of pollutional hazards. Where possible, the regulations governing this zone should be included in the city ordinances, or promulgated by the water district which might exist, and they should be strictly enforced by regular patrols.

Treatment plants. If potential sources of pollution exist in the immediate vicinity of raw water intakes, if no control of recreational activities is exercised, or if taste and odor problems are anticipated, facilities for prechlorination must be provided.

It is to be noted that the highest possible standards of sanitation are recommended, but variance of the controls upon recreational activity is sanctioned, provided prechlorination of the raw water is practiced continuously and there are facilities for coagulation, sedimentation, filtration, and postchlorination of the water at recommended rates of treatment.

Development of Regulation

The Texas Department of Health is of the opinion that reservoirs and watersheds should be developed in an orderly manner, beginning with the planning. The area of the reservoir which is subject to submergence should be cleared of vegetation to prevent pollution by timber and organic matter, thereby minimizing the possibility of the occurrence of severely undesirable tastes and odors in the raw water when the impounded water becomes available for treatment and distribution. Recreational areas should be designated during the early stages of reservoir development and the standards of sanitation to be maintained in these areas by the occupants or lessees should be prescribed by ordinance, or by rules and regulations adopted by district or river authority officials. In line with this phase of reservoir and marginal land sanitation control, it is desired to point out that the US Corps of Engineers, through its engineer on reservoir utilization, has been very cooperative and helpful to Texas in securing desired standards of sanitation within marginal areas of reservoirs constructed by the Corps, and in regulating recreational activity, where deemed necessary. The trend of suburban living and residential development within the marginal areas of reservoirs will also present problems

of sanitation, especially concerning liquid- and solid-waste disposal and potable water supplies. This type of development should also be placed under control during the early stages of reservoir development.

Uniform Regulation

The increased use of small boats, particularly of the outboard motor type, emphasizes the interest of the public in outdoor recreation. It is reported that approximately 1,000,000 boats are placed into operation each year, and that 25,000,000 persons took part in recreational boating in 1955. It is also reported that 65 per cent of all boats and motors sold are used primarily for fishing purposes. The operation of cabin cruisers with sanitary facilities, and of large fishing barges, is also increasing day by day.

Recently, the state of New Hampshire passed legislation (House Bill No. 78) to protect the waters of the state from pollution by pleasure boats equipped with marine toilets. The legislation provides that no such boats will be permitted to operate unless suitable waste treatment devices, approved by the New Hampshire Water Pollution Commission, are provided. Texas has not, as yet, established policies on the operation of such craft; however, the matter is presently under consideration. Water sports organizations are emphasizing their requests that controls at reservoirs serving as sources of public water supply be relaxed to provide needed recreational areas. With this growing public interest in outdoor recreation, and the current policies concerning the development of multipurpose water reservoirs, it is indicated that state public health departments and water pollution commissions should exert concerted efforts to standardize and to reappraise currently recommended watershed sanitation and management practices of public health significance.

With the development of reasonable rules and regulations covering the sanitation of reservoirs and marginal lands, which can be applied uniformly by the states without conflicting with existing statutes, it is believed that municipalities, water districts, water authority officials, water sports enthusiasts, and the public in general will appreciate the need for the restrictions recommended to be put into effect at reservoirs for public health protection. To safeguard the lives of patrons and visitors at these recreational areas, it should be recommended to responsible groups that these rules and regulations should also cover operation of boats, docks, rafts, and devices, the use of firearms, and the construction of docks, piers and wharves.

The state department of health desires, when request is made, to support fully any river authority, municipality, or water district in abating pollution in order to protect and preserve the purity of the water for human consumption. With the sanitary control powers given to river authorities, water districts, and municipalities to protect their watersheds, however, it is primarily the responsibility of these authorities to correct any pollution which might damage the use of the water under their control.

With a thorough understanding of this increasing problem and the available legal machinery, it is believed that the sanitary condition of water impounded in public water supply reservoirs will be assured.

—Penalties and Enforcement in Texas—*William H. Bell*—

A discussion prepared by William H. Bell, Legal Consultant, State Health Dept., Austin, Tex.

It would be useless to legislate and to create administrative agencies for the control and prevention of pollution if the power and scope of the legislation and agencies were not clearly defined. In all cases it should be clearly indicated [1] what penalties may be invoked against individuals or groups willfully violating antipollution statutes, and [2] which agencies (state, district, municipal, or other) have the responsibility of taking action against violators and what form this action may take.

Penalties

An indispensable requirement in antipollution legislation is that the statute itself provide the penalty for the violation of the rules and regulations prescribed by the administrative body. There must, in all cases, be statutory authority for declaring that an act amounts to a crime. In the Texas statutes this is found in the following language:

> Any violation of the provisions of this Act, or such rules and regulations, after due promulgation thereof, as hereinafter provided for, shall be unlawful, and shall be punished by a fine not to exceed the sum of $100, or imprisonment in the county jail of the county where such offense takes place, for a time not to exceed 30 days, or by both such fine and imprisonment. . . .

Further penalties for pollution exist (Article 7577):

> Any person who shall deposit in any canal, lateral, reservoir or lake, used for any purpose enumerated in this Act, the carcass of any dead animal, tin cans, discarded buckets or pails, garbage, ashes, baling or barbed wire, earth, offal or refuse of any character, or any other article or articles which might pollute the water or obstruct the flow in any such canal or other similar structure, shall be fined not less than $10 nor more than $100, or be imprisoned in jail for a term not exceeding 6 months, or be both so fined and imprisoned.

Enforcement

Watershed protection and management is a responsibility of river authorities, water districts, and municipalities. The legislature has passed laws regulating the rights of the public to the waters of the rivers and the lakes formed, and has provided for the protection of these rights by authorizing the board of directors to promulgate reasonable police and sanitary regulations.

The board of directors of any water district is given authority to bring suit to protect water rights. This authority (Article 7880-137) reads, in part, as follows:

> The board of directors are hereby empowered to institute and maintain any suit or suits to protect the water supply or other rights of the district and to prevent any unlawful interference with same or a diversion of its water supply by others. . . . All districts may sue and be sued in the name of the district by and through its board of directors.

River authorities have a legal as well as moral responsibility to prevent pol-

lution; it is pertinent, therefore, to examine the authority that municipalities have to correct this condition. Article 1175, Sec. 19, V.C.S., states that:

> Each city shall have the power . . . to prohibit the pollution of any stream, drain, or tributaries thereof, which may constitute the source of water supply of any city and to provide for policing the same as well as to provide for the protection of any watersheds and the policing of same. . . .

This authority applies to home rule cities; other cities are given the power "to abate all nuisances of every description which are or may become injurious to the public health, in any manner that they deem expedient." (Article 1072.)

Texas also has two antipollution statutes. One is a criminal statute (Article 698b, Texas Penal Code); the other is a civil statute (Article 4444) which permits the state regulatory authority to prevent pollution by injunctions. These statutes are brief, and the essence of each is simply that there shall be no pollution of any public waters by any person, firm, corporation, association, town, city, or other political subdivision of the state. The type of injunction that can be rendered under Article 4444 is indicated in the language used by the court in the injunction issued in the case of *Magnolia Petroleum Co.* v. *State,* 218 S.W. (2d) 855, where the defendants were enjoined from "throwing, casting, discharging, or depositing, directly or indirectly, salt water or other pollution substances . . . in the San Marcos or Guadalupe Rivers." It should be noted that no reference is made to any permissible quantity or degree of salt water allowed to be discharged into the rivers mentioned, but on the contrary, the decree literally prevented the discharge of any salt water into these streams, regardless of quantity. It might be said that these statutes constitute a simple commandment that "Thou shalt not pollute."

These statutes name the Texas health department as the state enforcement agency, except where fish and marine life are affected; then the authority is vested in the Texas Game, Fish and Oyster Commission. The first laws which served as a basis of the present statutes were passed as far back as 1913–17.

In another significant decision (*Weslaco* v. *Turner,* 237 S.W. (2d) 635) the court held, in effect, that the state board of health "is a necessary party in any cause of action in determining whether water, if it is a public body of water, is being polluted in violation of the provision of our pollution statute." In view of this decision the state health department is a necessary party in any cause of action that in the future may be brought by water districts or river authorities to abate the pollution of the water under their management.

The Texas health department desires, where request is made, to support fully any river authority or water district in abating pollution in order to protect and preserve the purity of the water for human consumption. With the sanitary control powers given to river authorities to protect their watersheds, however, it is primarily the responsibility of these authorities to correct any pollution which might damage the use of the water under their control.

Correlation of the Two Principal Methods of Calculating the Three Kinds of Alkalinity

John F. Dye

A paper presented on Sep. 13, 1956, at the Michigan Section Meeting, Kalamazoo, Mich., by John F. Dye, Plant Engr., Water Conditioning Plant, Board of Water & Elec. Light Comrs., Lansing, Mich.

THE property of alkalinity in a water is usually imparted by the presence of bicarbonates, carbonates, hydroxides, and—less frequently—by borates, silicates, and phosphates. In the proved absence of the latter three, the alkalinity is the sum of the first three. Numerically, it is the equivalent concentration of titratable base and is determined by titration with a strong acid to the carbonic acid equivalence point, the pH value of which varies from approximately 4.6 to 5.1—depending on the amount of carbonic acid resulting from the reaction of the carbonates and bicarbonates with the strong acid.

The phenolphthalein alkalinity (which might better be called the carbonate-hydroxide alkalinity) represents, stoichiometrically, the sum of the hydroxide alkalinity plus half the carbonate alkalinity. It is determined by titration with a strong acid to the bicarbonate equivalence point, the pH of which varies from approximately 8.5 to 8.3 in the temperature range 10°–30°C. At this equivalence point, the total carbon dioxide in the system is combined as bicarbonate and is equivalent to the total remaining titratable base.

The results of the titration for the phenolphthalein and total alkalinities are used to calculate the stoichiometric amounts of carbonate and either bicarbonate or hydroxide alkalinities. *Standard Methods* (*1*) shows in a table * the relations between the total and phenolphthalein alkalinities and the three forms of alkalinity. The values so obtained are widely used for water softening plant operation but, because they do not present a true picture as far as the ion concentrations are concerned, they cannot be used in any physiochemical calculations involving the laws of mass action or equilibrium constants—such as the calculation of the pH values used in determining Langelier's saturation index or Ryznar's stability index, or the calculation of the carbonate ion concentration used to determine the momentary excess of calcium carbonate.

This fact was first recognized by Langelier (*2*) when he presented equations for calculating the carbonate and bicarbonate ion concentrations and suggested that these and similarly derived equations for the hydroxide ion concentration and free carbon dioxide be included in *Standard Methods* to

* Table 5—Relationships Between Phenolphthalein Alkalinity, Total Alkalinity, Carbonate Alkalinity, Bicarbonate Alkalinity, and Hydroxide Alkalinity; p. 37, tenth edition.

supplement the discussion of alkalinity. Shortly thereafter, DeMartini (*3*), in a paper confirming the practical value of Langelier's theory, presented all four equations. This was followed by other papers (*4–6*) which supplied constants and corrections for temperature and mineral content and provided graphic means for calculating these ion concentrations. As a result, the ninth edition of *Standard Methods* included these equations and the tenth edition contains nomographs for determining these ion concentrations—in terms of calcium carbonate—from the pH value and total alkalinity of the water.

There has been a tendency by some to regard the results obtained by the titrations for total and phenolphthalein alkalinities as incorrect or, at least, very crude (*5*). To others, the idea of expressing the three kinds of alkalinities as ion concentrations has seemed to be too highly theoretical to be of much practical value. No serious attempt seems to have been made to present a correlation of the results obtained by the two methods or to explain the seeming discrepancies. Actually, the apparently anomalous results obtained by the two methods are like two views of the same landscape from widely separated points, each giving a true picture, but not necessarily the same or the whole picture. Each of the two methods of calculating the three kinds of alkalinity is invaluable for certain purposes; the one for theoretical calculations and the other for the more practical problems of plant operation. They are closely related and, at least in theory, each system can easily be converted to the other.

Hydrolysis Effects

In the absence of hydroxide, a solution of bicarbonate, carbonate, or both would not be alkaline if it were not for the fact that, being salts of weak acids and strong bases, they hydrolyze, causing an increase in the hydroxide ion concentration. At ordinary temperatures the hydrolysis of pure bicarbonate solutions yields only enough hydroxide ion to give a pH of about 8.35—regardless of the concentration of bicarbonate. Normally, phenolphthalein indicator shows only a faint pink color at this pH. The hydrolysis of the carbonate, however, produces enough hydroxide ions to affect markedly the pH value and the color of phenolphthalein indicator. In fact, at relatively high concentrations, pure solutions of soluble carbonate will have pH values in excess of 11.0.

Phenolphthalein Alkalinity

The carbonate ion is partially hydrolyzed according to the equation:

$$a(CO_3^{--})+xH_2O = x(HCO_3^-)+(a-x)(CO_3^{--}) + x(OH^-) \quad \ldots (1)$$

where a equals half the original carbonate ion concentration before hydrolysis and x equals the amount of carbonate that has hydrolyzed. In the titration for phenlophthalein alkalinity, the equivalents of phenolphthalein alkalinity equal equivalents of hydroxide alkalinity plus half the equivalents of carbonate alkalinity and since, in the hydrolysis of the carbonate (shown above) the decrease in carbonate ion is equal to the increase in hydroxyl ion, it follows that the equivalents of phenolphthalein alkalinity must also equal mols of OH^- plus mols of CO_3^{--} or,

$$P = [CO_3^{--}] + [OH^-] \quad \ldots (2)$$

where P represents phenolphthalein alkalinity. This equation is, strictly

speaking, only a close approximation, because the phenolphthalein titration does not determine all of the carbonate and hydroxide ions.* At pH 8.35, however, the hydroxide ion concentration remaining is negligible. For example, with a total-solids content of 200 ppm, the hydroxide ion concentration at this pH is only about 0.02 ppm at 5°C and 0.2 ppm at 30°C. The residual carbonate ion concentration at this pH is, of course, variable, the amount depending on the amount of remaining bicarbonate alkalinity. The total correction would be less than the usual error in the phenolphthalein titration and can therefore be ignored.

It is evident that the phenolphthalein alkalinity represents not only a measure of the hydroxide alkalinity plus half the carbonate alkalinity, but also the sum of the mols of hydroxide and carbonate ion concentrations, because the mol increase in hydroxide ion concentration upon hydrolysis is exactly equal to the mol decrease in carbonate ion concentration. It follows, therefore, that the phenolphthalein alkalinity can not only be determined by direct titration but may also be calculated as the sum of the hydroxide ion concentration as determined from the pH and the carbonate ion concentration as determined from the pH and total alkalinity.

Reverse Calculation

The reverse of this calculation may also be carried out. For all practical purposes, in the pH range above 8.35:

$$T = [HCO_3^-] + 2[CO_3^{--}] + [OH^-] \quad (3)$$

* In this and all other equations, unless otherwise stated, the phenolphthalein and total alkalinities and the ion concentrations are expressed as $CaCO_3$ ppm equivalents.

where T is total alkalinity. From this equation and Eq 2 is obtained:

$$[CO_3^{--}] = P - [OH^-] \quad (4)$$

and

$$[HCO_3^-] = T - 2P + [OH^-] \quad (5)$$

which make it possible to calculate the carbonate and bicarbonate ion concentrations from the total and phenolphthalein alkalinities and the pH of the water. If it can be demonstrated that, with a particular water, the pH of the phenolphthalein endpoint coincides with the pH of the bicarbonate endpoint, the values for the ion concentrations obtained by these calculations are sufficiently accurate for many purposes.

Determination of pH From *P* and *T*

It would often be desirable, especially in the laboratories of water softening plants, to be able to determine the pH of a water from the total and phenolphthalein alkalinities. If the accuracy of the phenolphthalein titration has been established for the water under consideration, it is possible to determine the pH indirectly from the phenolphthalein and total alkalinities by evaluating the hydroxide ion concentration from these alkalinities and, from this, calculating the pH for the particular conditions of temperature and total-solids content.

From the well known equations for the equilibrium constants, K_w' and K_2', it can be shown that:

$$\frac{[CO_3^{--}]}{[HCO_3^-]} = \frac{2K_2' \times [OH^-]}{K_w' \times 10^5} \quad (6)$$

where $[OH^-]$, $[CO_3^{--}]$, and $[HCO_3^-]$ are in terms of ppm $CaCO_3$ and K_w' and K_2' represent the ionization constant for water and the second ionization constant for carbonic acid, respec-

tively—corrected for temperature and dissolved solids.

By substituting the values for $[CO_3^{--}]$ and $[HCO_3^{-}]$ from Eq 4 in Eq 6, this becomes:

$$\frac{2K_2'[OH^-]}{K_w' \times 10^5} = \frac{P - [OH^-]}{T - 2P + [OH^-]} \quad (7)$$

from which is obtained the quadratic equation:

$$[OH^-]^2 + [OH^-]\left[(T - 2P) + \left(\frac{K_w' \times 10^5}{2K_2'}\right)\right] - P\left(\frac{K_w' \times 10^5}{2K_2'}\right) = 0 \quad (8)$$

The $[OH^-]$ in Eq 8 can be solved for, nomographically, by use of the chart shown in Fig. 1 if the temperature–dissolved solids constant (TDS):

$$\frac{K_w' \times 10^5}{2K_2'}$$

is first determined by use of the small auxiliary nomograph contained on the chart. The pH corresponding to the $[OH^-]$ value found can then be obtained by use of the nomograph for the evaluation of hydroxyl ion concentration * in *Standard Methods*.

For many plants, the conditions of temperature and dissolved solids do not fluctuate very much and it is possible to use a simpler chart constructed for the particular conditions. In such circumstances, the numerical value for the TDS constant can be substituted in Eq 7 and the chart then constructed. As an example, at the Lansing, Mich., water conditioning plant, where a ground water is softened, the dissolved-solids content is about 200 ppm in the finished water and the temperature of the water when titrated is about 15°C all year. The TDS constant becomes 5.234 for these conditions. By substituting this value in Eq 7 and rearranging, the recurrent variable type of equation is obtained:

$$T + 5.234 - P\left(\frac{5.234 + 2[OH^-]}{[OH^-]}\right) = -[OH^-] \quad (9)$$

from which the chart in Fig. 2 was constructed. It should be noted that because the temperature and dissolved solids are assumed to be constant, it was possible to construct the center scale as an alignment chart showing both $[OH^-]$ and pH.

Using the value for $[OH^-]$ found with either chart, the values for $[CO_3^{--}]$ and $[HCO_3^{-}]$ can be calculated to an accuracy sufficient for most purposes by use of Eq 4 and 5. For more exact work, by using the pH found and the total alkalinity, the carbonate and bicarbonate ion concentrations may be determined by use of the nomographs for the evaluation of carbonate and bicarbonate alkalinity † in *Standard Methods* or the equations on which these nomographs are based.

One advantage of constructing a three-variable chart—such as that in Fig. 2—is that it can be used in reverse; that is, it can be used to calculate rapidly the phenolphthalein alkalinity from the pH and total alkalinity, provided, of course, that dissolved solids and the temperature at which the pH is determined are about the same as those for which the chart was constructed.

In the calculations for the construction of these charts, the values used for

* Fig. 7, p. 54, tenth edition, *Standard Methods* (*1*).

† Fig. 8 and 9, pp. 55 and 56, tenth edition, *Standard Methods* (*1*).

the ionization constants, K_2 and K_w, are those of Harned and associates (*7*, *8*). The corrections for dissolved solids are those presented by Larson and Buswell (*5*).

Total Carbon Dioxide

It might be of interest here to consider the role that the total carbon dioxide content plays in determining

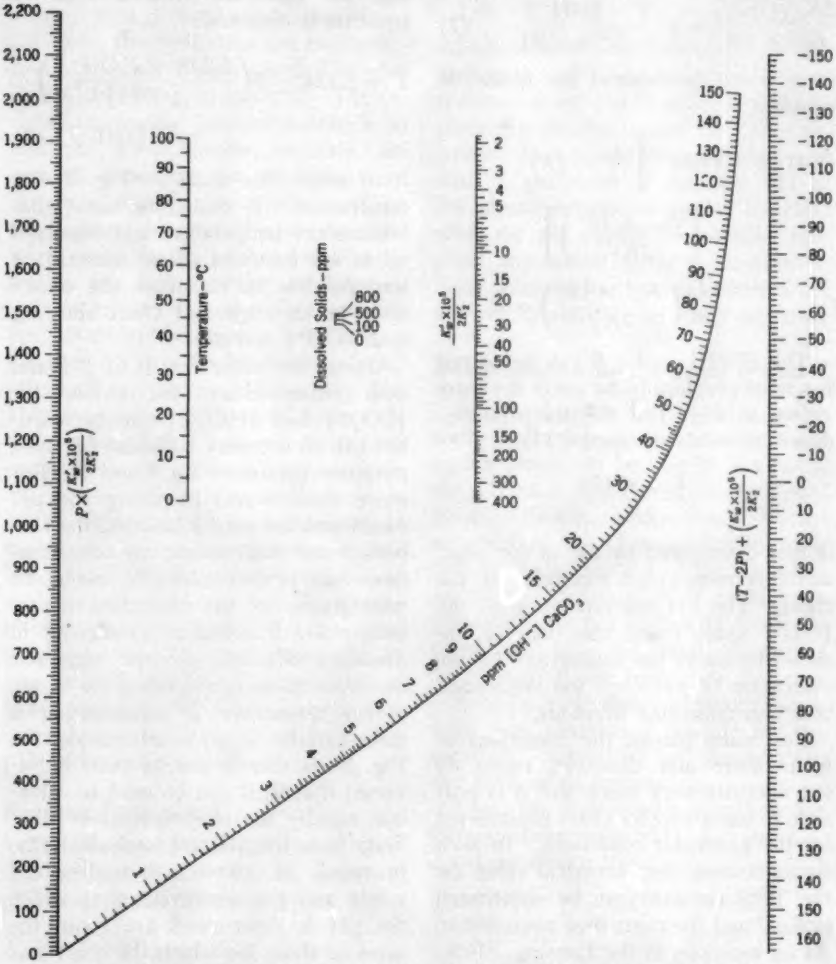

Fig. 1. Nomograph for Evaluation of Hydroxide Ion Concentration

Valuation, as ppm $CaCO_3$, is made from total alkalinity (T), *corrected phenolphthalein alkalinity* (P), *and temperature–dissolved solids constant* (TDS). *The last is obtained by use of the small auxiliary nomograph.*

the phenolphthalein alkalinity. McKinney (*9*), Amorosi and McDermet (*10*), and others have pointed out the significance of dissolved carbon dioxide in water and especially its relationship to the concentrations of carbonic acid and the bicarbonate and carbonate ions. In the pH range considered in this paper—that is, above about 8.35, in which range all of the carbon dioxide may be assumed to be combined as bicarbonate and carbonate—the stoichiometric amounts of the three kinds of alkalinity (bicarbonate, carbonate, and hydroxide) depend upon the relative amounts of the total carbon dioxide and total alkalinity. From this it can be seen that the phenolphthalein alkalinity also is dependent upon the relative amounts of total carbon dioxide and total alkalinity. If McKinney's (*9*) notation is adopted, and $[C]$ represents total carbon dioxide, then:

$$[C] = [HCO_3^-] + [CO_3^{--}] \quad (10)$$

If Eq 10 is subtracted from Eq 3, then

$$T - C = [CO_3^{--}] + [OH^-] \quad (11)$$

and, substituting in Eq 2:

$$P = T - [C] \quad (12)$$

where brackets indicate concentrations and both the alkalinities and concentrations are in terms of ppm $CaCO_3$.

If this value for phenolphthalein alkalinity from Eq 12 is substituted in Eq 8, an expression is obtained by which the hydroxide ion concentration (and, of course, indirectly, the pH) is related to the total carbon dioxide content and total alkalinity of a water, provided the carbon dioxide content (as $CaCO_3$), is not greater than twice the total alkalinity. This value for phenolphthalein alkalinity from Eq 12 may also be substituted for use with the nomographs Fig. 1 and 2 which are based on Eq 2; that is, in Fig. 1, $(T - 2P)$ becomes $(2C - T)$ and in both nomographs P becomes $(T - C)$. The relationship between total carbon dioxide and total and phenolphthalein alkalinities might have some value in calculating the amounts of carbon dioxide to use for recarbonation after excess-lime softening.

Use of Nomographs

The nomograph of Fig. 1 was developed from Eq 8 and is intended for use over a wide range of temperatures and contents of dissolved solids. In fact, by using the phenolphthalein and total alkalinities determined at or below room temperature—either by titration or by calculation—it is possible to determine the ppm $[OH^-]$ and, from this, the pH value for any temperature within the range of the small auxiliary nomograph.

Figure 2 was developed from Eq 9 and should not be used if the temperature at which the pH is desired or was determined varies appreciably from 15°C. The dissolved-solids content assumed for this nomograph is 200 ppm but, because the ionic strength affects the ion concentrations much less than does the temperature, not much error is incurred if the chart is used for waters with dissolved solids contents of 100–300 ppm.

A few examples of the use of the nomographs in Fig. 1 and 2 are given below. The answer checks shown are for the mathematical correctness only.

Example 1

With a phenolphthalein alkalinity of 22, a total alkalinity of 53, and dissolved solids equal to 500 ppm, what

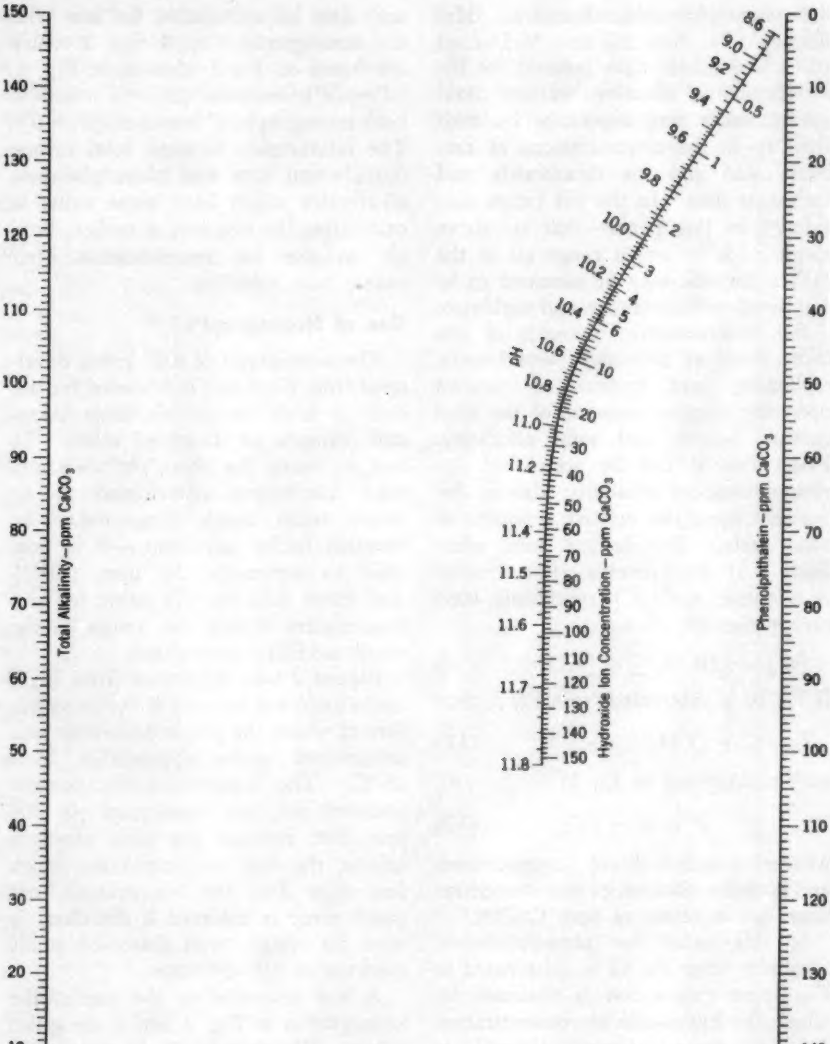

Fig. 2. Nomograph for Evaluation of Hydroxide Ion Concentration and pH

Chart applies only to waters with about 200 ppm dissolved solids and results are correct only for temperatures of about 15°C.

is the pH at 20°C? From the auxiliary nomograph, the TDS constant is 6.5. For the left-hand scale, $P \times 6.5 = 143$; for the right-hand scale, $(T - 2P) + 6.5 = 15.5$. A straight line through these values intersects the center scale at 6.4 ppm $[OH^-]$. Then, by use of the nomograph for evaluation of hydroxyl ion concentration (Fig. 7, tenth edition *Standard Methods*), at 20°C and 200 ppm dissolved solids, the pH is found to be 10.22. To check results, the nomograph for evaluation of carbonate alkalinity (Fig. 8, tenth edition *Standard Methods*) shows, at 20°C and 200 ppm dissolved solids, a value for $[CO_3^{--}]$ of 15.2 ppm. Hence, $P = 15.2 + 6.4$, or 21.6. This is a sufficiently close check when using nomographic solutions.

Example 2

With a phenolphthalein alkalinity of 55, a total alkalinity of 85, and dissolved solids equal to 200 ppm, what is the pH at 12°C? The TDS constant is 4.4. For the left-hand scale, $P \times 4.4 = 242$; for the right-hand scale, $(T - 2P) + 4.4 = -20.6$. From the center scale $[OH^-]$ is 28.8 ppm. The pH at 12°C and 200 ppm dissolved solids is found to be 11.17. Checking as in Example 1, $[CO_3^{--}]$ is 26 ppm and phenolphthalein alkalinity is $26 + 28.8$, or 54.8.

Example 3

Using the same data as in Example 1, what would be the pH at 60°C? The TDS constant for 60°C and 500 ppm dissolved solids is 54. $P \times 54 = 1188$. $(T - 2P) + 54 = 63$. The $[OH^-]$ is found to be 15.2 ppm and the corresponding pH value is 9.45. The $[CO_3^{--}]$ is found to be 6.7 ppm. Phenolphthalein alkalinity is $15.2 + 6.7$, or 21.9 ppm. It should be noted that even though the pH value is lowered as the temperature is raised, the ppm $[OH^-]$ increases. This, together with the fact that the solubility product constant for magnesium hydroxide decreases with an increase in temperature, explains the tendency of some lime-treated waters, when heated, to deposit scales that are mixtures of calcium carbonate and magnesium hydroxide, although the scales deposited by the same waters in cold-water pipes and mains are mostly calcium carbonate.

Example 4

With a phenolphthalein alkalinity of 13, a total alkalinity of 35, dissolved solids equal to 200 ppm, and a temperature of 15°C, what is the pH and the carbonate ion concentration? Using the nomograph in Fig. 2, a line from 35 on the left-hand scale to 13 on the right-hand scale intersects the center scale at pH 10.21, and gives an $[OH^-]$ of 3.9 ppm. The carbonate ion concentration (from Eq 2) equals $13 - 3.9$, or 9.1 ppm. The carbonate ion concentration as calcium carbonate alkalinity is $2[CO_3^{--}]$ or 18.2 ppm. A check is made by using the nomograph for evaluation of carbonate alkalinity (Fig. 8, tenth edition *Standard Methods*), where $2[CO_3^{--}]$ is found to be about 18.4 ppm.

Laboratory Confirmation

After the nomograph shown in Fig. 2 was prepared several years ago for use at the Lansing, Mich., water conditioning plant, the pH values obtained by its use were checked frequently with those obtained with the glass electrode. For the most part, the

differences were small—less than 0.1 and often less than 0.05, although, occasionally, much wider deviations were found. Several series of tests were made, and Table 1 shows the results of a group of such tests made on samples of water from municipal water treatment plants.

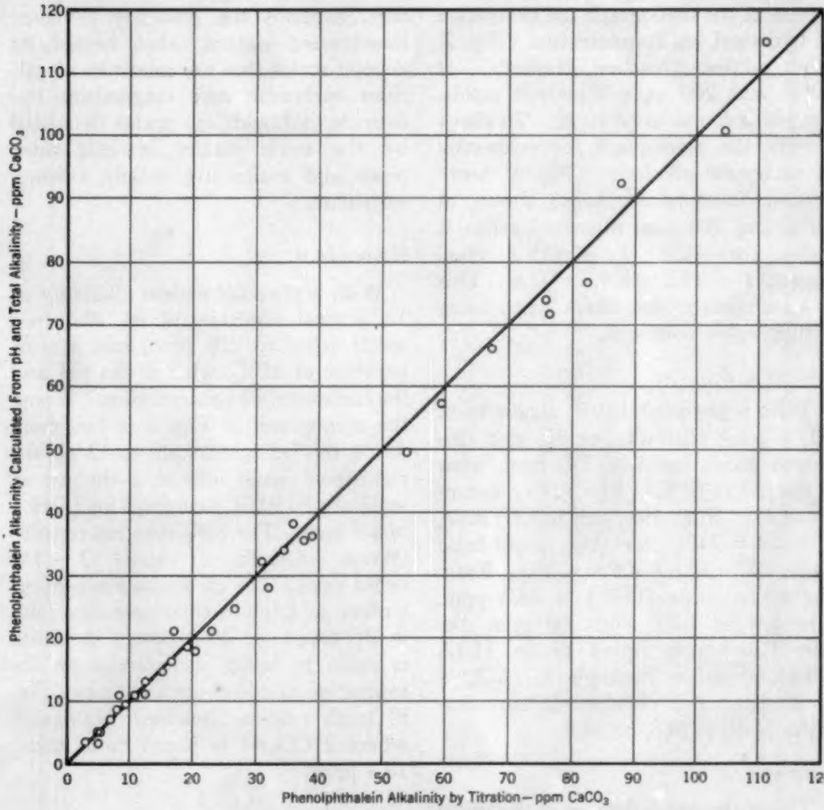

Fig. 3. Calculated and Titrated Phenolphthalein Alkalinity

Figure is derived from data shown in Table 1.

In this first series of tests, an attempt was made to obtain a fairly wide range of total alkalinities and pH values. In the series shown in Table 2, however, the samples are entirely synthetic, being made up to obtain a range of alkalinities such as might be encountered in lime-soda softening and to obtain a wide spread of pH values in each range.

Apparatus and Techniques

The pH meter used for the determinations was standardized against pH 7.0 and pH 10.0 standard buffer solutions. When adjusted for the pH 10.0

buffer, a check against the pH 7.0 buffer showed at no time a deviation of more than 0.02 and it was therefore assumed that the readings made for the pH range included in these tests were sufficiently accurate for the purpose.*

For the alkalinity determinations, a 10-ml buret, graduated in 0.05-ml divisions, was used. A 100-ml sample was used for the titrations and the titrant used was 0.02*N* hydrochloric acid. The indicator for most of the total alkalinity titrations was brom cresol green–methyl red indicator. This was adjusted so that the colorless endpoint occurred at pH 5.1. Methyl orange indicator was used in the titrations for the last four alkalinities in Table 1. When using mixed indicator, all samples were titrated to the colorless endpoint except samples 16–20 in Table 2. For these higher alkalinities, the titrations were carried to a faint pink color, which corresponded to a pH of about 4.9. The endpoints for many of the phenolphthalein and total-alkalinity titrations were checked with the glass electrode.

* Meter used was a Beckman Model G, manufactured by Beckman Instruments, Inc., Beckman Division, South Pasadena, Calif.

TABLE 1

pH Values Obtained With Nomograph of Fig. 2 Compared With Those Obtained With Glass Electrode

Sample*	Temperature °C	pH (Actual)	Total Alkalinity	Phenolphthalein Alkalinity (Actual)	pH†	Phenolphthalein Alkalinity‡
1	21.0	11.45	119.0	111.0	11.42	115.4
2	22.0	11.17	84.5	76.0	11.20	74.0
3	21.0	9.30	34.0	3.0	9.17	3.7
4	21.0	9.25	33.0	5.0	9.34	3.4
5	20.0	9.50	48.0	7.0	9.46	7.1
6	20.0	9.59	49.5	10.0	9.74	8.3
7	17.5	10.88	43.0	31.0	10.86	32.2
8	19.0	10.29	39.0	20.5	10.44	18.0
9	25.0	10.82	41.0	36.0	10.78	38.5
10	22.5	10.61	42.5	32.0	10.73	28.1
11	23.0	11.11	84.0	76.5	11.17	71.7
12	22.0	9.81	456.0	110.0	9.88	104.9
13	22.0	9.00	371.0	17.0	8.94	21.0
14	18.0	11.39	389.0	219.0	11.30	224.0
15	18.0	10.46	238.0	88.0	10.41	92.6

* Samples 1–6 are from primary flocculating and secondary and final settling basins at Lansing, Mich.; 7–11 are mixtures from primary and secondary settling basins at same plant; and 12–15 are from a municipal cation-exchange softening plant and were modified by the addition of sodium hydroxide and by dilution with distilled water.
† Calculated from total and phenolphthalein alkalinities.
‡ Calculated from pH and total alkalinity.

On comparing the actual pH values with the calculated values, it will be noted that most of the calculated values are higher than the actual values and, conversely, most of the values for the phenolphthalein alkalinities calculated from the total alkalinities and actual pH values are lower than those obtained by titration. Figures 3 and 4—plots of the actual phenolphthalein alkalinities and pH values compared with the calculated values for

these characteristics in the two series of tests—demonstrate this point graphically.

A consideration of the principal source of error encountered in making the titration for phenolphthalein alkalinity seems to confirm these results. Almost invariably, in this titration, some carbon dioxide escapes and, as a result, does not convert its share of the remaining carbonate to bicarbonate. More acid is therefore required to reach the endpoint, and the reported results are usually high. Some authorities recommend chilling the sample to near 0°C to minimize the escape of carbon dioxide. In making the titrations reported in Tables 1 and 2, the titrant was introduced below the surface of the sample and a magnetic stirrer was used to lessen the loss of carbon dioxide. Of course, the practice of agitating the sample violently during the titration or of titrating in

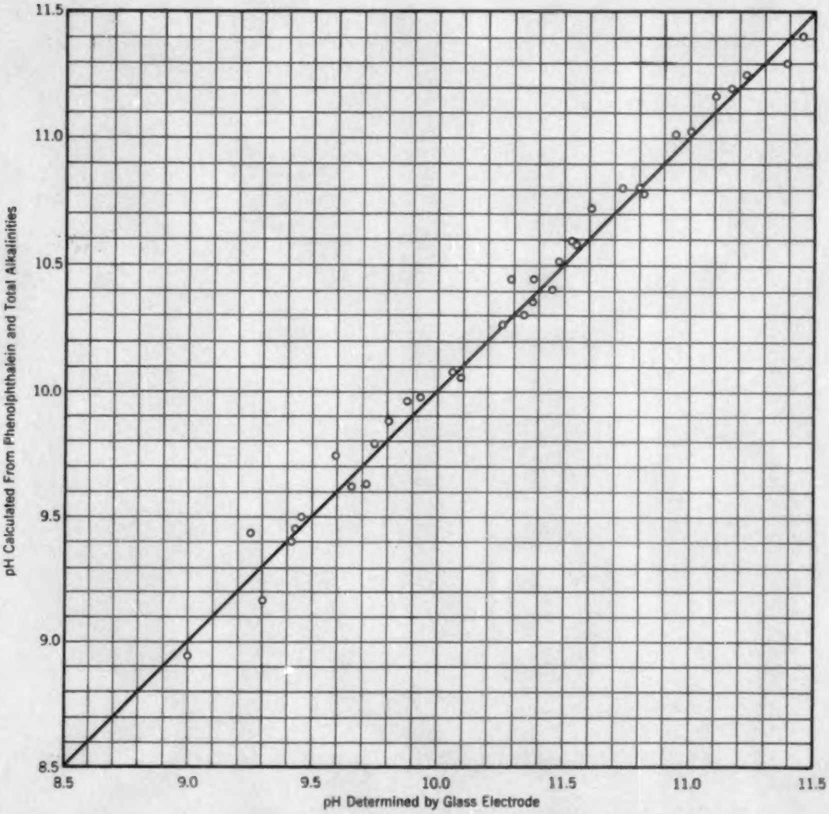

Fig. 4. Actual and Calculated pH Values

Figure is derived from data shown in Table 2.

a shallow dish also leads to high results for the same reason.

It is felt that the results shown in the tables and in Fig. 3 and 4 demonstrate the essential correctness of the theory presented here. These plots definitely indicate more than just a trend. In fact, they illustrate all too well the inaccuracy of the phenolphthalein endpoint which has been pointed out by DeMartini (*3*) in connection with the titration for free carbon dioxide. There is no reason to expect this indicator to be much more reliable when titrating with an acid and approaching the endpoint from the alkaline side than it is when titrating with an alkaline titrant and approaching the endpoint from the acid side.

Conclusions

If the shortcomings of the phenolphthalein titration are taken into consideration, the results of the laboratory tests—as shown in Tables 1 and 2 and Fig. 3 and 4—seem to prove the correctness of the author's assumptions and of Eq 2–12, which are based on these assumptions.

If the validity of the theory of the relationships between the ionic and the stoichiometric forms of alkalinity in the pH range above approximately 8.35, as presented in this paper, is accepted, a means has been provided for the conversion from one alkalinity system to the other and for a check on the accuracy of the phenolphthalein titration. It follows also that where

TABLE 2

Comparison of pH Values Obtained With Nomograph and Glass Electrode From Prepared Samples*

Sample	Temperature °C	pH (Actual)	Total Alkalinity	Phenolphthalein Alkalinity (Actual)	pH†	Phenolphthalein Alkalinity‡
1	21.0	9.66	25.0	5.3	9.62	5.2
2	21.0	9.75	19.5	5.0	9.79	5.2
3	21.0	10.09	21.4	9.0	10.06	9.2
4	22.0	10.34	20.8	12.6	10.31	13.0
5	23.0	10.48	20.8	16.7	10.52	16.2
6	23.0	9.72	38.2	7.5	9.63	8.6
7	23.5	9.88	38.0	12.5	9.97	11.1
8	23.5	10.26	40.0	19.2	10.27	18.6
9	23.5	10.53	39.7	26.8	10.59	24.8
10	23.5	10.80	40.3	34.5	10.81	34.4
11	24.0	9.42	77.5	9.5	9.40	9.5
12	24.0	9.93	76.2	23.0	9.98	21.1
13	25.0	10.38	78.5	39.0	10.45	36.3
14	25.0	10.73	78.7	54.0	10.81	49.8
15	25.0	11.01	79.0	67.5	11.03	66.0
16	25.0	9.43	115.6	15.2	9.45	14.5
17	24.0	10.06	116.0	37.7	10.08	35.6
18	25.0	10.55	115.7	59.5	10.58	57.3
19	24.0	10.94	118.5	82.5	11.02	76.8
20	24.0	11.23	118.7	104.5	11.26	100.5

* Samples were prepared by adding sodium bicarbonate and sodium hydroxide solutions to boiled distilled water.
† Calculated from total and phenolphthalein alkalinities.
‡ Calculated from pH and total alkalinity.

the titration for phenolphthalein alkalinity is proved to be unreliable, a means has been provided for the calculation of this value from the pH and total alkalinity of a water.

It is suggested that a further proof of the validity of the Langelier, DeMartini, and Moore equations for determining the ionic forms of alkalinity and also the corrections for temperature and mineral content supplied by Larson and Buswell can now be established. This can be done by making use of the fact that the stoichiometric phenolphthalein alkalinity is constant over a wide range of temperature while the degree of hydrolysis and, of course, the resulting pH varies with

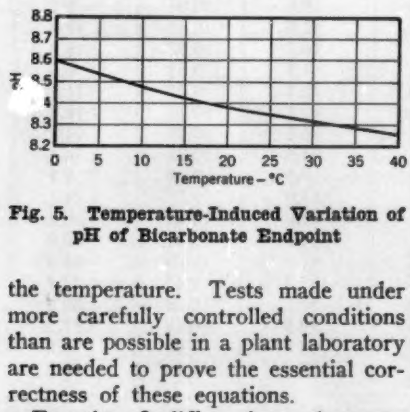

Fig. 5. Temperature-Induced Variation of pH of Bicarbonate Endpoint

the temperature. Tests made under more carefully controlled conditions than are possible in a plant laboratory are needed to prove the essential correctness of these equations.

Equation 2 differs from that presented some time ago by Larson and Buswell (*5*), but it is correct if bracketed figures are taken to indicate ion concentrations rather than the stoichiometric values. Larson and Bushwell's equation $P = \frac{1}{2}[CO_3^-] + [OH^-] - [HCO_3^-]$, is evidently intended to be used with the results obtained from the titrations for phenolphthalein and total alkalinities but will often give negative results if ion concentrations are used for the quantities in the brackets.

Determinations of pH are not of much value if the temperature at which they are made is not stated; colorimetric pH tests are, similarly, of doubtful value except for approximations. It should be standard procedure to use a glass electrode which has been standardized against a buffer solution of a pH which is in the range of the tests and to report both the pH found *and the temperature*—for example, pH 9.08 at 18°C. This is common procedure for many laboratory tests the results of which are affected by temperature. For example, in oil testing, the temperature at which the test is made is always given when reporting Baume and viscosity readings. In pH determinations, the difference may be considerable. If a water which has a pH of 10.94 at 5°C is warmed to "room temperature"—for example, 23°C—the pH will drop to about 10.37. Even the terms "room temperature" or "ambient temperature" are very misleading, for these can vary from approximately 20°C to 30°C depending on latitude, season of the year, and the presence or absence of air conditioning. Temperature is a very real "fourth dimension" in all physicochemical experiments and tests.

Unless plant operators are well trained and their laboratory techniques checked frequently, the phenolphthalein and total-alkalinity titrations are often hastily and perfunctorily made and the endpoint for the former is usually overrun, with the result that readings tend to be high. Such control tests are not of much value for the determination of pH from the phenolphthalein and total alkalinities as described in this article. Under the best

of conditions and when made by well trained and conscientious chemists or technicians, the phenolphthalein titration is subject to inaccuracies caused by the loss of carbon dioxide during the titration and by the nature of the indicator endpoint, which is a slow fading from red to colorless and not a sharp color change. There is need for an indicator with a sharp color change at about pH 8.4, preferably of the mixed-indicator type, and with which, by varying the ratios of the two indicators, the endpoint pH can be adjusted to allow for the temperature-induced variations in the pH of the bicarbonate endpoint. Figure 5 shows this variation.

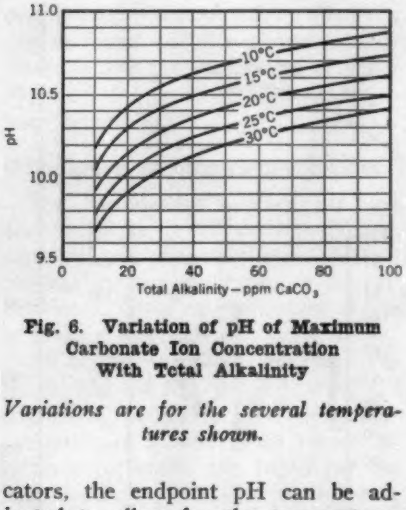

Fig. 6. Variation of pH of Maximum Carbonate Ion Concentration With Total Alkalinity

Variations are for the several temperatures shown.

Applications

The relationship between pH, the ion concentrations, the total carbon dioxide, and the total and phenolphthalein alkalinities has many applications.

For example, the pH of maximum carbonate ion concentration for the total alkalinity in a water should be important in some water treatment processes. Where a water is treated with excess lime followed by recarbonation to precipitate the excess or where selective calcium carbonate removal is used, it may be necessary to treat so that all of the alkalinity is in the form of carbonate in order to obtain the maximum precipitation of calcium carbonate. If soda ash is used in addition to lime, an appreciable saving is effected if the final total alkalinity is driven to the lowest value consistent with good practice from the standpoint of protection against corrosion. At the point of maximum carbonate ion concentration, $2P = T$, but the pH varies widely with temperature and total alkalinity. Figure 6 shows this variation in the temperature range 10°–30°C and for alkalinities of 10–100 ppm. As can be seen, the pH of maximum carbonate ion concentration is definitely above 10.0 and often well above 10.5 in the usual temperature and alkalinity ranges encountered in water softening. It is not between 9.0 and 10.0, as has sometimes been indicated in the literature.

The pH of maximum carbonate ion concentration is also of importance in the calculation of the saturation index of a water. The formula generally used for calculating saturation index if the actual pH of the sample exceeds 10.0 is $10.0 - pH_s$ where pH_s is the pH a water must have—with no change in total alkalinity and calcium content—to be just saturated with calcium carbonate. The pH of 10.0 was selected because it was assumed to be the pH of maximum carbonate ion concentration at 25°C. A pH greater than that of maximum carbonate ion concentration is caused by calcium hydroxide—in water softening plant ef-

fluents—but does not enter into the equation for the pH of saturation of calcium carbonate. The indiscriminate use of pH 10.0 as the average pH of maximum carbonate ion concentration may lead to large errors in the calculation of the saturation index. A more accurate procedure would first determine the pH of maximum carbonate ion concentration for the alkalinity and temperature of the sample. If the actual pH is higher than the pH of maximum carbonate ion concentration, then the saturation index is calculated by subtracting the pH_s from the latter.

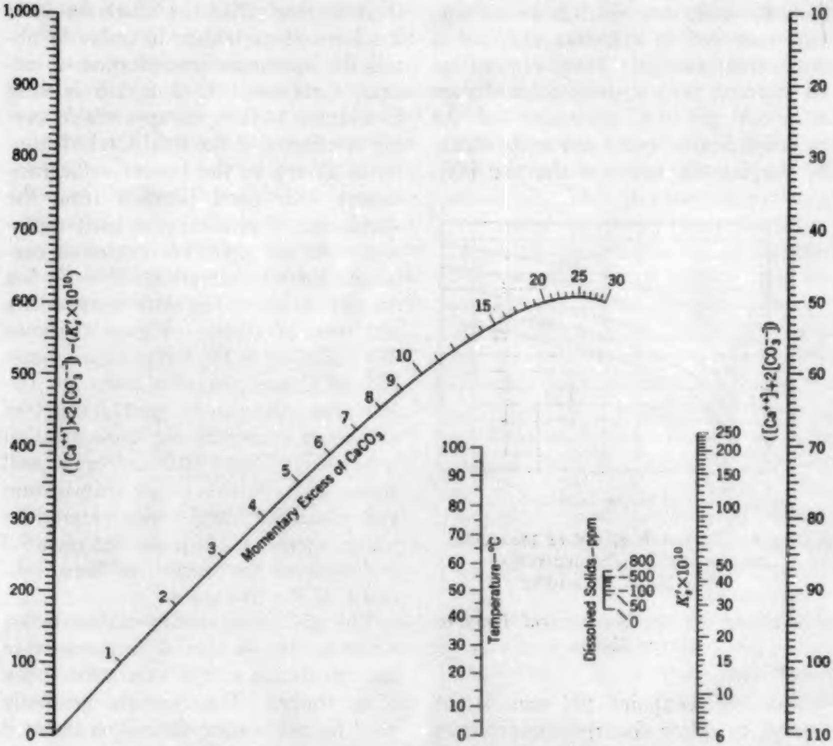

Fig. 7. Nomograph for Evaluation of Initial or Momentary Excess of $CaCO_3$

Chart is based on equation $([Ca^{++}] - x) \times ([CO_3^{--}] - x) = K'_s \times 10^{10}$, *where* $[Ca^{++}]$ *and* $[CO_3^{--}]$ *are initial concentrations of calcium and carbonate ions (in ppm* $CaCO_3$*), x is ppm* $CaCO_3$ *that must precipitate to satisfy the equation, and* K'_s *is the solubility product constant, corrected for temperature and dissolved solids.*

Maintenance of Saturation Index

Another application of the relationships discussed is in the maintenance of a definite saturation index. Ordinarily, the pH values of a softening

plant effluent will not change much from day to day. It is, therefore, a relatively simple matter to maintain a definite saturation index by keeping the pH constant at the value required to produce it. For any given alkalinity, there is a phenolphthalein alkalinity that will give this pH. By use of Fig. 2 or a similar chart constructed for the particular conditions of temperature and mineral content, or by the use of Fig. 1 of this article and the charts for hydroxide and carbonate ion concentrations in *Standard Methods,* the desired phenolphthalein alkalinity can be found and the amount of carbonation (or the percentage of water bypassed for split treatment) regulated accordingly.

Calculation of Momentary Excess

The relationship between pH, ion concentrations, total carbon dioxide, and total and phenolphthalein alkalinities has another application in the calculation of initial or momentary excess of calcium carbonate.

All of the theoretical indexes proposed (*2, 11, 13*) for indicating the degree of undersaturation or supersaturation of a water with respect to calcium carbonate are based on the equation for the solubility product constant for calcium carbonate: $(Ca^{++}) \times (CO_3^{--}) = K_s'$, where parentheses indicate molal concentrations and K_s' is the solubility product constant corrected for temperature and dissolved solids. This equation may be satisfied in two ways; one way involves the dissolving or precipitating of calcium carbonate—depending on whether the water is undersaturated or supersaturated. This involves the principle of the marble test described by Hoover (*10*).

The equation can also be satisfied by an increase or decrease in the total carbon dioxide. The Langelier saturation index is based on this principle and on the fact that the pH of a water is determined by its total alkalinity and the total (combined and free) carbon dioxide content. The saturation index is the number obtained by subtracting the pH_s—previously defined—from the actual pH of the water, a plus sign indicating scale-forming tendencies and a minus sign indicating a tendency to dissolve calcium carbonate. As has been stated by others, this index is not quantitative, but indicates a directional tendency only. With the same value of positive index, a water with a high pH_s will deposit much less scale than a water with a low pH_s.

A more quantitative measure of a water's degree of supersaturation with respect to calcium carbonate may be obtained if the equation for the solubility product constant is modified to read:

$$[(Ca^{++}) - x] \times [(CO_3^{--}) - x] = K_s' \quad (13)$$

where x represents the mols of $CaCO_3$ that must precipitate to satisfy the equation and (Ca^{++}) and (CO_3^{--}) represent the mols of calcium and carbonate ions before precipitation. By solving this equation for x, the initial or momentary excess can be determined. This gives a quantitative measure of the driving force for the precipitation of calcium carbonate. A similar value could also be calculated for the initial or momentary deficiency by making x positive.

If the concentrations in Eq 13 are expressed in terms of ppm $CaCO_3$ and the equation is expanded, it becomes:

$$\{([Ca^{++}] \times 2[CO_3^{--}]) - (K_s' \times 10^{10})\} - x([Ca^{++}] + 2[CO_3^{--}]) = -x^2 \quad (14)$$

This is a recurrent-variable type of equation, easily solved by nomographic means. The nomograph shown in Fig. 7 was constructed to solve this equation.

A similar chart has been used for several years at the Lansing water conditioning plant. The plant effluent would be scale forming if it were not

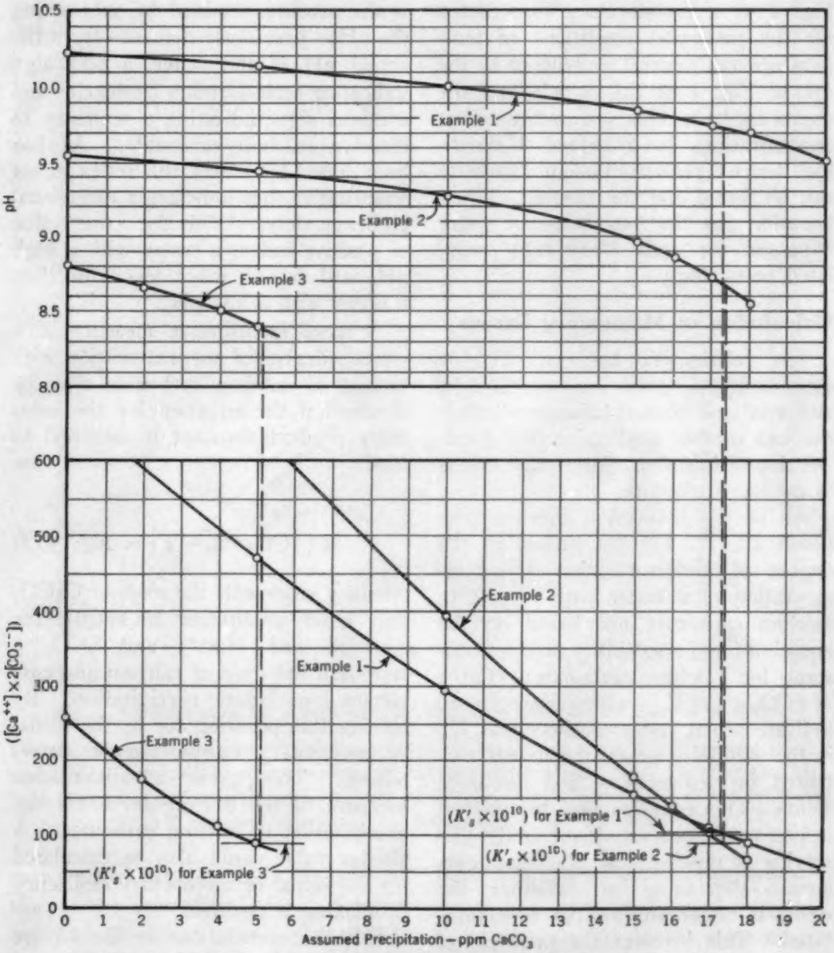

Fig. 8. Method of Determining Total Excess $CaCO_3$ and Final pH

Data for examples shown are given in text.

for the addition of about 0.25 ppm polyphosphate to the suction lines of the high-head pump. A comparison of the theoretical momentary excess and the actual amount precipitated—as determined by passing the water through an Enslow stability apparatus—gives a measure of the protection obtained by the use of the polyphosphate. Here, a rapid calculation of the carbonate ion concentration is obtained by subtracting the hydroxide ion concentration—as obtained by use of the nomograph in Fig. 2—from the phenolphthalein alkalinity. Calcium is determined by the usual EDTA titration, using murexide indicator. The value for $K_s' \times 10^{10}$—found by use of the auxiliary nomograph (Fig. 1b)—is subtracted from the product of the calcium and carbonate ion concentrations. A straight line between this value on the left-hand scale and the sum of the ion concentrations on the right-hand scale will cut the curve at the value representing the momentary excess of calcium carbonate.

Calculation of Total Excess $CaCO_3$

Another application is in calculation of the total excess calcium carbonate. The total amount of calcium carbonate that can precipitate is, of course, greater than the momentary excess. Langelier has shown (*12*) how to determine this total excess at 25°C and 75°C. By the method given below, the total excess may be calculated for any ordinary temperature.

It should be remembered that carbonate ion hydrolyzes according to the equation: $CO_3^{--} + H_2O \rightleftarrows HCO_3^- + OH^-$, and, since the reaction is reversible, as soon as some of the ion is removed by precipitation, more is formed by a shift to the left in this equation. This equilibrium follows the laws of mass action and may be represented by the equation:

$$K_h = \frac{(HCO_3^-) \times (OH^-)}{(CO_3^{--})}$$

where K_h is the hydrolysis constant for this particular reaction. As more carbonate ion is formed, calcium carbonate precipitates until all equilibria are satisfied.

As calcium carbonate precipitates, there is, of course, a reduction in total alkalinity and total carbon dioxide. The phenolphthalein alkalinity is reduced by half the reduction in total alkalinity. By assuming several values for the amount of calcium carbonate

TABLE 3

Tabulation for Calculating Graphically the Total Excess Calcium Carbonate in Example 1, Fig. 8

Item	Initial Assumptions						Check
$CaCO_3$ precipitated	0	5	10	15	17	18	17.3
Total alkalinity	31	26	21	16	14	13	13.7
Phenolphthalein alkalinity	12	9.5	7	4.5	3.5	3.0	3.35
$[Ca^{++}]$	42.5	37.5	32.5	27.5	25.5	24.5	25.2
pH	10.21	10.12	10.01	9.85	9.75	9.69	9.73
$[OH^-]$	3.9	3.2	2.45	1.7	1.36	1.18	1.3
$[CO_3^{--}]$ or $(P - [OH^-])$	8.1	6.3	4.55	2.8	2.14	1.82	2.05
$[Ca^{++}] \times 2[CO_3^{--}]$	672	472	296	154	119	89	103.3

precipitated, new total alkalinities, theoretical phenolphthalein alkalinities, and calcium hardnesses can be calculated. Then, for each pair of phenolphthalein and total alkalinities, the ppm $[OH^-]$ and, from this, the pH value may be obtained nomographically. The ppm $[CO_3^{--}] = P - [OH^-]$ (Eq 1). The product of $[Ca^{++}] \times 2[CO_3^{--}]$ may then be plotted against the ppm $CaCO_3$ assumed to be precipitated—as in Fig. 8. A horizontal line drawn at the value for $K_s' \times 10^{10}$—as determined by use of the nomograph shown in Fig. 7—intersects the curve at a point which gives the total excess of calcium carbonate that can precipitate. If the pH is plotted for each reduction in calcium carbonate—as in Fig. 8—the pH at equilibrium may also be determined.

In Fig. 8 is shown the method of plotting the product of the residual calcium and carbonate ion concentrations (as ppm $CaCO_3$), as calcium carbonate is precipitated to determine the total excess and the final pH value. In the figure, Example 1 was worked out as shown in Table 3. For this water the dissolved solids amount to 200 ppm, the temperature is 15°C, and $K_s' \times 10^{10}$ equals 102 for these conditions. As can be seen from the figure, after the precipitation of about 17.3 ppm $CaCO_3$, the product of $[Ca^{++}] \times [CO_3^{--}]$ is about equal to $K_s' \times 10^{10}$ and the pH will be about 9.73. The final residual $CaCO_3$ will be about 25.2 ppm. In these examples, more assumptions were made—for the purpose of showing the complete curves—than would be necessary in routine calculations.

In Example 2 of Fig. 8, the initial pH is 9.60; total alkalinity, 50; phenolphthalein alkalinity, 10; calcium, 60 ppm; temperature, 25°C; and dissolved solids, 400 ppm. At equilibrium, about 17.4 ppm $CaCO_3$ will have precipitated, leaving 42.5 ppm calcium as $CaCO_3$ with the pH about 8.66.

In Example 3, the initial pH is 8.80; total alkalinity, 100; calcium, 35 ppm; temperature, 25°C; and dissolved solids, 400 ppm. For pH and total alkalinity, phenolphthalein alkalinity is 4.1. At equilibrium, about 5.1 ppm $CaCO_3$ will have precipitated, leaving 29.9 ppm residual calcium as $CaCO_3$ with the pH about 8.38.

A comparison of the final excess with the momentary excess may be of interest. In Example 1, the momentary excess is 12.3 ppm; in Example 2, 13.8 ppm; and in Example 3, 4.6 ppm.

Other Applications

Other applications for the conversion from one alkalinity system to the other will probaby occur to the interested reader. It should be of value when dealing with the effect of a change in temperature or when studying the effect of a predictable or actual change in stoichiometric alkalinities, any of which may bring about a shift in equilibrium that will increase or decrease the concentrations of carbonate or hydroxide ions. For instance, the use of a nomograph constructed for a particular set of conditions—such as that in Fig. 2—facilitates the accurate calculation of the pH_s in such a way that corrections to the total alkalinity for the value

$$\left(\frac{K_w'}{[OH^-]}\right)$$

and for the effect of dissolved solids are applied automatically. The method

is based on the fact that a change in the pH of a water is effected by a change in the total carbon dioxide content which can be measured by the change in phenolphthalein alkalinity. In this method it is first necessary to obtain the value $K_s' \times 10^{10}$ for the water from the nomograph in Fig. 7. Then, using Fig. 2, the ppm $[OH^-]$ and the phenolphthalein alkalinity can be determined from the pH and total alkalinity. The ppm $[CO_3^{--}]$ can then be calculated by use of Eq 2. If the product of $[Ca^{++}] \times 2[CO_3^{--}]$ is less than $K_s' \times 10^{10}$, the saturation index is negative. If the product is greater than this constant, the index is positive. Assuming several values for pH, calculations can then be made of ppm $[CO_3^{--}]$ and the value for the product of $[Ca^{++}] \times 2[CO_3^{--}]$. Plotting these values against the pH values assumed, gives a curve which cuts a line drawn for the constant $K_s' \times 10^{10}$ at a point which is the pH_s for the water.

The calculation of the total excess of magnesium hydroxide is another function of this method that may be of some importance to water chemists. This would be significant in determining the effectiveness of lime treatment for removal of the magnesium hydroxide—with and without the use of another coagulant. The amount of magnesium hydroxide that might be expected to precipitate in hot water heaters would also be of some interest and the method used would be similar to that given above to calculate the total excess of calcium carbonate.

Summary

This article has presented a theory regarding the relations between the stoichiometric and ionic systems of alkalinity in the pH range above the bicarbonate endpoint. Laboratory confirmation is given, both in tabular and graphic form.

Two nomographs have been presented which facilitate the conversion from one alkalinity system to the other by solving equations based on the theory. The method of using the nomographs is explained and some applications are suggested—including the calculation of the momentary excess of calcium carbonate, for which another nomograph is presented.

Acknowledgment

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Joint Committee on Certification and Training

On Apr. 25, 1958, the AWWA Board of Directors adopted a proposal for the formation of a joint committee of AWWA and the Conference of State Sanitary Engineers on certification and training of water utility personnel.

Among other activities, the joint committee will:

1. Collect and summarize information on certification plans and training courses
2. Promote the certification of water utility personnel in all states and prepare material for that purpose
3. Develop a suggested uniform plan for voluntary certification
4. Develop a suggested uniform act for compulsory certification
5. Cooperate with committees and any agencies developing training manuals and augment such manuals as may be necessary to prepare personnel for certification
6. Develop guides for training courses
7. Develop a uniform examination
8. Work for reciprocity between states
9. Collect information on qualifications and salaries of water utility personnel.

Study of Methods for the Determination of Nitrates

Arnold E. Greenberg, John R. Rossum, Nathan Moskowitz, and Primo A. Villarruz

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IN the Tenth Edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* (*1*), two methods are given for the determination of nitrate ions in water: the phenoldisulfonic acid and reduction methods. Each of these is time consuming and, as will be shown, is not always accurate or precise in the hands of some chemists. For these reasons, an attempt was made to find a method which would overcome some of these limitations.

The use of the alkaloids, brucine and strychnine, as colorimetric reagents for nitrate has been known for many years (*2, 3*). These procedures have given extremely erratic results and have had the added disadvantage of requiring the handling of highly toxic reagents. The brucine procedure adopted by ASTM (*4*) is based largely on the studies of Haase (*5*) in 1926 and Noll (*6*) in 1945. This particular procedure has been modified in the laboratory of the California Water Service Co. so that it is now believed that a rapid, relatively accurate procedure is available. Basically, the test involves the reaction between the nitrate ion and brucine to give a colored end product. The intensity of color is a function of concentration, and, although Beer's law is not obeyed, the simultaneous development of color in standards and samples permits quantitative estimation of the nitrate concentration.

This article will describe the modified brucine procedure and, furthermore, compare this method with the standard procedures.

Experimental Procedure

Three samples of water, representing low, moderate, and high concentrations of nitrate, were collected. Each sample was divided into two portions, to one of which was added a known amount of potassium nitrate. Each of these six portions was further divided so that it was possible for two laboratories (the California Water Service Co. laboratory and the sanitation laboratory of the California Department of Public Health) simultaneously to begin analysis of the six samples. Each laboratory analyzed each sample ten times by each of three methods: phenoldisulfonic acid, reduction, and brucine. The

TABLE 1

Comparison of Laboratory Methods for Determining Nitrate in Water

Sample	Nitrate Added (as NO_3) *mg/l*	Laboratory	Phenoldisulfonic Acid Method: Nitrate (as NO_3) *mg/l* Mean	Phenoldisulfonic Acid Method: Nitrate Variance	Phenoldisulfonic Acid Method: Coefficient of Variation *per cent*	Phenoldisulfonic Acid Method: Recovery *per cent*	Reduction Method: Nitrate (as NO_3) *mg/l* Mean	Reduction Method: Nitrate Variance	Reduction Method: Coefficient of Variation *per cent*	Reduction Method: Recovery *per cent*	Brucine Method: Nitrate (as NO_3) *mg/l* Mean	Brucine Method: Nitrate Variance	Brucine Method: Coefficient of Variation *per cent*	Brucine Method: Recovery *per cent*
A	none	1	0.75	0.0406	27.0		0.13	0.0090	73.0		0.24	0.0225	68.7	
		2	*				0.20	0.0049	34.3		*			
A	7.94	1	8.06	0.0138	1.45	92.1	7.15	0.0117	1.51	88.5	7.93	0.0242	1.96	96.9
		2	8.52	0.0377	2.28	107.3	2.56	0.229	18.7	29.7	7.89	0.297	6.91	99.4
B	none	1	7.96	0.0338	2.31		7.48	0.0173	1.77		8.15	0.0527	2.81	
		2	7.51	0.273	6.96		4.77	0.192	9.21		8.41	0.132	4.32	
B	15.87	1	24.01	0.199	1.86	101.1	22.76	0.287	2.38	96.3	23.85	0.625	3.32	98.9
		2	25.90	0.300	2.11	115.8	15.84	0.805	5.66	69.8	24.63	0.595	3.14	102.2
C	none	1	32.92	0.400	1.92		30.63	0.667	2.67		31.86	0.337	1.82	
		2	32.23	2.195	4.60		22.58	0.502	3.14		32.47	1.190	3.37	
C	20.00	1	53.53	0.209	0.85	103.1	50.90	1.776	2.62	101.4	51.60	3.184	3.46	98.7
		2	55.15	3.761	3.51	114.7	36.67	5.240	6.24	70.5	52.36	2.951	3.29	99.5

Classification of Waters

Sample	pH	Chloride *mg/l*	Alkalinity *mg/l*	Nitrite	Source
A	8.3	5.0	34	none	reservoir—suitable for domestic use with chlorination only
B	7.9	20.5	202	none	deep well—suitable for domestic use with no treatment
C	8.0	57.0	188	none	deep well—suitable for domestic use with no treatment

* None found.

procedures given in *Standard Methods* (*1*) were followed for the first two, and the method described in the appendix to this article was used for the third.

Results

A total of 360 nitrate determinations were made. After tabulating the data, a number of statistics were derived: the average, the variance, the standard deviation (the square root of the variance), the coefficient of variation (the standard deviation expressed as a percentage of the mean), and the percentage of recovery. These values are shown in Table 1.

Inspection of the data in Table 1 shows that with regard to accuracy (as measured by recovery) and precision (as measured by the coefficient of variation) the brucine method yields better results than the other two procedures.

It is evident that neither the phenoldisulfonic acid nor the reduction procedure is consistently poor, but rather that each one is affected by the laboratory using it. The phenoldisulfonic acid method as used in Laboratory 1 gave reproducible (except when the nitrate content was close to zero) and relatively accurate results. In the other laboratory, however, the results were reasonably precise but not accurate, since a consistent positive error of at least 7.3 per cent was observed.

Using the reduction method, Laboratory 1 had reproducible results which tended to be low by comparison with the other methods and with the known amount of nitrate added. Laboratory 2 obtained results which were neither accurate (consistent negative error) nor precise. An intensive investigation of the reduction method was made in Laboratory 2, where the method of evaporation in pretreatment of the sample, type of alkali (NaOH and KOH) in pretreatment, quantity and source of aluminum, time of reduction, type of alkali in the reducing system (NaOH and KOH), temperature of reduction, and the distillation procedure were studied. No explanation for the low values was obtained. These low recoveries were consistent with past experience in this laboratory, which had led to this cooperative investigation. It is interesting to note that the precision and accuracy reported here are worse than those stated in *Standard Methods* (*1*).

Discussion

It is clear that even in the hands of experienced water chemists reliable results are not always obtained by using either of the two presently accepted standard methods. Both laboratories followed the procedure given in *Standard Methods* to the letter, so that the difference in results of the two laboratories must be ascribed to minor differences in technique or reagents. On the other hand, the proposed brucine procedure yields more reliable results and is more uniformly accurate and precise. Thus, it would appear that, on the basis of results reported here, the proposed method is preferable to the standard methods. The brucine procedure has the advantage over the others in speed and simplicity. It requires neither overnight reduction nor evaporation to dryness. Results can be obtained within 1 hr, with about 30 min of working time.

There are certain disadvantages to the brucine method:

1. Brucine is toxic, and care must be exercised in handling it.

2. The small sample taken (2 ml) necessitates the use of scrupulously clean pipets and careful technique in

order to avoid large pipeting errors. The recovery data indicate that these errors are not serious when reasonable precautions are used.

3. Work not reported here has indicated that the method is not suitable for samples containing less than approximately 1 mg/l or more than approximately 10 mg/l nitrogen. When the nitrate nitrogen is less than 1 mg/l, the hydrolysis of organic nitrogen compounds limits the dependability of the brucine as well as the standard methods. In that event, the method of Westland and Langford (*7*) would appear suitable.

Conclusions

A method for the determination of nitrate in water has been described and compared with the standard methods of analysis. The proposed brucine method is appreciably simpler and less time consuming than the standard methods. Furthermore, the brucine procedure appears to be more precise and accurate. Its accuracy and precision over the range of 1–10 mg/l nitrogen are both about 3 per cent, as indicated by the recovery and coefficient of variation.

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APPENDIX

Suggested Modified Brucine Procedure for Nitrate Determination

1. General Discussion

1.1. *Principle.* The reaction between nitrate and brucine yields a sulfur yellow color employed for colorimetric estimation. The color system does not obey Beer's law, although in plotting transmission against nitrate concentration, a smooth curve is produced. It is necessary simultaneously to develop color in a series of standards and samples. The intensity of the color is measured at 410 mμ.

The intensity of the maximum color produced varies more or less inversely with the temperature, while the rate of color development varies more or less directly with the temperature. The temperature generated upon mixing sulfuric acid with water can be controlled by adjusting the acid con-

centration. Both the acid concentration and the reaction time have been selected to yield optimum results and to compensate for any normal variations in room temperature.

1.2. *Interference.* All strong oxidizing or reducing agents interfere. The presence of oxidizing agents may be determined by the addition of orthotolidine reagent as in the measurement of chlorine residual. The interference by residual chlorine may be eliminated by the addition of sodium arsenite, provided that the chlorine residual does not exceed 5 mg/l. A slight excess of sodium arsenite will not affect the determination. Divalent and trivalent iron and quadrivalent manganese give slight positive interferences, but in concentrations less than 1 mg/l these are negligible. The interference due to nitrites is eliminated by the use of sulfanilic acid. Chlorides do not interfere.

2. Apparatus

2.1. *Colorimetric equipment.* One of the following is required:

a. Spectrophotometer, for use at 410 mμ, providing a light path of 1–5 cm.

b. Filter photometer, providing a light path of 1–5 cm, and equipped with a blue filter having maximum transmittance between 400 and 425 mμ.

3. Reagents

3.1. *Sulfuric acid solution,* 90 per cent. Carefully add 500 ml of concentrated H_2SO_4 to 75 ml distilled water. Cool to room temperature before use. Keep tightly stoppered to prevent absorption of atmospheric moisture.

3.2. *Brucine–sulfanilic acid reagent.* Dissolve 1 g brucine sulfate and 0.1 g sulfanilic acid in approximately 70 ml of hot distilled water. Add 3 ml concentrated HCl, cool, and make up to 100 ml. This solution is stable for several months. The pink color that develops slowly does not affect its usefulness. (Caution: Brucine is toxic. Care must be taken to prevent ingestion.)

3.3 *Sodium arsenite solution,* approximately 0.028*N*. Dissolve 1.83 g $NaAsO_2$ in 1 liter of distilled water. Prepare fresh every 6 months. (Caution: Sodium arsenite is toxic. Care must be taken to prevent ingestion.)

3.4. *Stock nitrate solution.* Dissolve 0.722 g anhydrous KNO_3 and dilute to 1.0 liter with distilled water. This solution contains 100 mg/l nitrogen.

3.5. *Standard nitrate solution.* Dilute 50.0 ml stock nitrate solution to 500 ml with distilled water. (1 ml = 0.01 mg N = 0.0443 mg nitrate ion.)

4. Procedure

4.1. *Preparation of standard curve.* Prepare nitrate standards in the range 0.0–10.0 mg/l by diluting appropriate quantities of the standard nitrate solution to 100 ml with distilled water. Suggested volumes of standard nitrate solution (1.0 ml = 0.01 mg N) are: 0, 5, 15, 25, 35, 50, 75, and 100 ml. Treat 2.0 ml of each solution as described under Sec. 4.3, and determine the photometer reading.

4.2. *Pretreatment of sample.* If the sample contains Cl_2, remove it by adding 1 drop (0.1 ml) arsenite solution for each 0.05 mg Cl_2, and mix. Add 1 drop in excess to a 50-ml portion.

4.3. *Analysis of sample.* Carefully pipet 2.0 ml of sample containing not more than 10 mg/l nitrogen into a 50-ml beaker. Add 1 ml brucine–sulfanilic acid reagent, using a safety

pipet. Into a second 50-ml beaker measure 10 ml of 90 per cent H_2SO_4. An automatic buret is convenient for this purpose. (Note: The intensity of color is affected slightly by the heat capacity of the containers. The concentration of H_2SO_4 has been chosen so that normal variations in heat capacities of beakers will not affect the result. It is important, however, that only 50-ml beakers be used.) Mix the contents of the two beakers by carefully adding the sample brucine–sulfanilic acid reagent to the beaker containing acid. Pour from one beaker to the other four to six times to insure mixing. Allow the treated sample to remain in the dark for 10 ± 1 min. The beakers may conveniently be covered with cardboard cartons during this period. While the samples are standing for color development, measure 10 ml distilled water into the beaker that originally contained the acid. After 10 min add the water to the sample and mix as before. Allow to cool in the dark for 20–30 min. Set the blank at 100 per cent transmittance at a wavelength of 410 mμ. It is advisable to run a series of standards with each set of samples. With a proper arrangement of work, as many as twelve samples may be determined in a batch along with eight standards.

5. Calculation

Read amount of nitrogen from the calibration curve. Then:

$$\text{mg/l N} \times 4.43 = \text{mg/l } NO_3$$

Proposed Standard Methods for Boron Determination

Committee Report

A report made under the jurisdiction of Committee 8930 P—Standard Methods for the Examination of Water, Sewage, and Industrial Wastes (Michael J. Taras, Chairman), by a group composed of Remo Navone (Chairman), Lester L. Louden, Eugene Goldman (Adviser), and R. P. Grady (Adviser).

The Standard Methods Committee of AWWA intends, from time to time, to present proposed methods for various constituents of water. These methods will be presented after appropriate subcommittee and committee consideration for eventual inclusion in the Eleventh Edition of Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. *The objective of this policy will be to encourage the broader use of the new methods with a view to learning their limitations. Comments, suggestions, and criticisms are invited on the proposed boron methods, as well as on all procedures in the Tenth Edition. Please address all pertinent remarks to the American Water Works Association, 2 Park Ave., New York 16, N.Y.*

THE determination of boron in waters, industrial wastes, and sewage effluents is important from the standpoint of agriculture. Boron in excess of 2.0 mg/l in irrigation water is deleterious to certain plants, and there is evidence that some plants are adversely affected by concentrations as low as 1.0 mg/l. Boron may be determined in water, sewage, and industrial wastes by a colorimetric method using curcumin (A) or by an electrometric titration method (B).

Selection of method. The colorimetric method is used in determining concentrations from 0.10 to 1.0 mg/l photometrically, but that range may be extended by diluting the original sample. A visual comparison adaptation is also presented for boron concentrations in the 0.025–0.20-mg/l range. The electrometric titration method can be used to determine boron in the range from 0.10 to 5 mg/l in natural waters, and higher concentrations of boron can be determined by taking a suitable aliquot. The colorimetric determination offers some advantages over the electrometric titration. Only a 1-ml sample is needed, contrasted with the 250-ml volume required in the titration method. In addition, the former may be used as a rapid test for the presence of boron. The electrometric titration, on the other hand, is especially suitable because of its accuracy and application to waters of high boron concentration.

A. Colorimetric Method

1. General Discussion

1.1. *Principle.* When a sample of water containing boron is acidified and evaporated in the presence of curcumin, a red-colored product called rosocyanine is formed. The rosocyanine is taken up in a suitable solvent, and the red color is compared with standards visually or photometrically.

1.2. *Interference.* Ions commonly found in water do not interfere with this method, except nitrates at concentrations above 20 mg/l, as nitrate nitrogen.

1.3. *Storage of samples.* Samples should be stored in polyethylene bottles or alkali-resistant, boron-free glassware.

2. Apparatus

2.1—*Colorimetric equipment:*

a. Spectrophotometer, for use at 540 mμ, with minimum light path of 1 cm *or*

b. Filter photometer, equipped with a filter having a maximum transmittance in the region of 540 mμ.

2.2. *Selected round cuvettes,* 19 × 105 mm (may also be used as color comparison tubes).

2.3. *Evaporating dishes,* 50–250-ml capacity, of platinum, porcelain, Vycor,* or glass.

2.4. *Water bath,* set at 55° ± 2°C.

3. Reagents

3.1. *Curcumin–oxalic acid solution.* Dissolve 0.040 g of finely ground curcumin (Eastman No. 1179 or equivalent) and 5.0 g oxalic acid in 80 ml of 95 per cent ethyl alcohol. Add 4.2 ml concentrated HCl and make solution up to 100 ml with ethyl alcohol in a 100-ml volumetric flask. (Isopropyl alcohol, 95 per cent, may be used in place of ethyl alcohol.) This reagent will be stable for several days, if stored in the refrigerator.

3.2. *Standard boron solution* A. Dissolve 0.5716 g dry boric acid in distilled water and dilute to 1 liter; 1 ml = 0.100 mg B (100 μg).

3.3. *Standard boron solution* B. Dilute 10 ml of standard boron solution *A* to 1 liter with distilled water; 1 ml = 1 μg boron.

3.4. *Ethyl alcohol,* 95 per cent.

4. Procedure

4.1. *Preparation of calibration curve.* Pipet 0.00 (blank), 0.25, 0.50, 0.75, and 1.00 μg boron into platinum, porcelain, or glass evaporating dishes. Evaporating dishes used must be of the same type, shape, and size. Add 4.0 ml curcumin–oxalic acid reagent and swirl dish gently to mix contents thoroughly. Float dishes on a water bath set at 55° ± 2°C and allow to evaporate to dryness. Remove each dish from bath as soon as contents appear dry. Allow to cool, and add 20.0 ml ethyl alcohol. Stir contents gently with a polyethylene rod to insure complete solution of the red-colored product. If solutions are turbid, filter into 19 × 105-mm cuvettes through filter paper (Whatman No. 30 is satisfactory).

Read transmittance of solutions at 540 mμ, setting blank at 100 per cent. Plot a reference curve of boron concentration versus transmittance. The calibration curve is linear from 0.00 to 1.00 μg boron. If desired, optical density of the solutions may be read, setting the blank at zero density.

4.2. *Procedure for water.* For waters containing 0.10–1.00 mg/l boron, use 1 ml of sample. For

* Manufactured by Corning Glass Works, Corning, N.Y.

waters containing more than 1.00 mg/l boron, make an appropriate dilution with boron-free distilled water, so that a 1-ml aliquot contains approximately 0.50 μg boron.

Pipet the 1 ml of sample or dilution into a platinum, porcelain, or glass evaporating dish. Unless the calibration curve is being determined at the same time, prepare a blank and a standard containing 0.50 μg boron and run it in conjunction with the unknown. Proceed as in Sec. 4.1, beginning with "Add 4.0 ml curcumin–oxalic acid reagent. . . ." Obtain boron content from calibration curve.

4.3. *Visual comparison.* The photometric method may be adapted to visual estimation of low boron concentrations, from 0.05 to 0.20 mg/l, as follows: Dilute boron standard *B* so that 1 ml equals 0.20 μg boron. Pipet 0.00, 0.05, 0.10, 0.15, and 0.20 μg boron into the evaporating dishes as indicated in Sec. 4.1. At the same time, add an appropriate volume of sample (1 ml or less) to an identical evaporating dish. The boron content of the sample taken should be between 0.05 and 0.20 μg. Proceed as in Sec. 4.1, beginning with "Add 4.0 ml curcumin–oxalic acid reagent. . . ." Compare color of unknowns with standards. All colorimetric readings should be made within 1 hr after solution of the red color in the alcohol.

5. Calculation

When using optical density readings, the following formula may be used in calculating boron concentration:

$$\text{mg/l boron} = \frac{(O.D.)_2}{(O.D.)_1} \times C \times \frac{1{,}000}{S}$$

in which: $(O.D.)_1$ is optical density of standard sample, $(O.D.)_2$ is optical density of unknown sample, C is milligrams of boron in standard sample taken, and S is volume of sample of water in milliliters.

6. Precision and Accuracy

Experience has shown that with the photometric procedure the standard deviation is ± 0.10 mg/l, with an average deviation of ± 0.08 mg/l in the range of 0.10–1.00 mg/l of boron.

The method requires close control of all variables, such as volumes and concentrations of reagents, as well as time and temperature of drying. Evaporating dishes must be identical in shape and size, as well as composition, to insure equal evaporation time. Increasing the time of evaporation will result in intensifying the resulting color.

B. Electrometric Titration Method

1. General Discussion

1.1. *Principle.* When a dilute solution containing boric acid or borate is neutralized and then treated with mannitol, there is produced a complex acid which can be titrated with dilute NaOH. The amount of boron is proportional to the amount of NaOH needed to return the pH of the solution to the initial pH.

1.2. *Interference.* Phosphate reacts with mannitol but not quantitatively, and if the phosphate concentration exceeds 10 mg/l, it should be removed. This can be done by precipitation with lead nitrate, followed by removal of the excess lead with sodium bicarbonate. Germanium and tetravalent vanadium react like boron, but are not normally present in water supplies. Buffer substances, such as carbonate, ammonia,

or phosphate, may interfere by decreasing the sharpness of the endpoint. The absorption of acidic or alkaline gases from the laboratory air during the course of the titration may cause a drift of the meter and resultant error.

Hydrochloric acid or ammonia should not be permitted in the room while boron titrations are being carried out. The error from atmospheric carbon dioxide can be minimized by titrating rapidly. The titration of the blanks and standards, if carried out under conditions as closely similar as possible to those of the sample titrations, will nearly compensate for any carbon dioxide error.

1.3. *Sampling and storage.* Samples should be collected and stored in boron-free glass or polyethylene bottles. Borosilicate (pyrex) bottles should not be used.

2. Apparatus

2.1. *A buret,* so calibrated that the volume can be read to 0.01 ml.

2.2. *Glassware.* Borosilicate (pyrex) beakers can be used, but new beakers should be cleaned by filling with dilute acid and heating on a steam bath.

2.3. *Motor stirrer or magnetic stirrer.*

2.4. *Electrical equipment.* Either a potentiometer (*8*) or a pH meter sensitive to 0.01–0.05 pH may be used as an indicating system, set so that at balance the solution under test will have a pH of 7.0. The glass-saturated calomel electrode pair commonly used in pH measurements is satisfactory.

3. Reagents

3.1. *Bromthymol blue indicator,* 1 per cent aqueous solution.

3.2. *Sulfuric acid solution,* approximately 1*N*.

3.3. *Sodium hydroxide solution, saturated.* To prepare a carbonate-free solution dissolve 50 g NaOH in 50 ml distilled water and let stand at least 48 hr in an alkali-resistant container (wax-lined or polyethylene), protected by a CO_2 trap.

3.4. *Sodium hydroxide solution, approximately 0.5* N, *carbonate free.* Dilute 2.9 ml supernatant-saturated NaOH solution to 100 ml with freshly boiled distilled water. Prepare fresh each day.

3.5. *Standardized sodium hydroxide solution.* Measure a volume of the supernatant, carbonate-free saturated NaOH solution to give approximately 1 g NaOH and dilute to 1 liter with CO_2-free distilled water. Standardize against 5.00 ml standard boric acid solution plus 250 ml distilled water as described in the procedure. Dilute with CO_2-free distilled water so that 1.00 ml equals 0.250 mg boron. Store in a boron-free container (low-boron glass bottle, paraffin-lined bottle, or polyethylene bottle) protected by a CO_2 trap, filled with soda-lime or other absorbent such as Ascarite.*

3.6. *Standard boric acid solution.* Dissolve 0.5716 g dry H_3BO_3 in distilled water and dilute to 1 liter (1 ml = 0.1000 mg boron).

3.7. *Mannitol, boron free.* The blank titration for 5 g mannitol should not exceed 0.1 ml standardized NaOH.

3.8. *Standard buffer, pH 7.00,* commercially prepared for standardizing a pH meter.

4. Procedure

4.1. Transfer 250 ml of the sample to a 400-ml tall-form beaker. This should contain not more than 1 mg elemental boron. If the sample is high

* Available from Arthur H. Thomas Co., Philadelphia, Pa.

in boron, an aliquot portion diluted to 250 ml should be taken.

4.2. Add a few drops of bromthymol blue indicator and acidify with $1N$ H_2SO_4 adding 0.5–1 ml in excess. Bring to a boil and stir—cautiously at first, then vigorously—to expel carbon dioxide. Cover and cool to room temperature, preferably in a water bath.

4.3. Standardize the pH meter to 7.00 with standard buffer solution. Wash electrodes thoroughly with distilled water, and introduce the electrodes into the solution to be titrated. Add carbonate-free $0.5N$ NaOH to approximately pH 5.0. Solution is gently stirred during titration procedure.

4.4. Adjust solution to exactly pH 7.00 with the standardized NaOH solution (Sec. 3.5). This is the initial point of the titration.

4.5. Add 5 ± 0.1 g mannitol. If boron is present, the indicator will change to the acid color, and the pH meter will show an acid pH. Add standardized NaOH solution until the pH meter indicates pH of 7.00. Note the number of milliliters of standardized NaOH solution required after adding mannitol at the initial point of the titration.

4.6. Determine a reagent blank by using 250 ml boiled distilled water instead of the sample. Proceed as indicated above, beginning with Sec. 4.1.

4.7. It is advisable to run a standard boron solution (0.500 mg boron) in conjunction with the unknown in order to check reagents and technique.

5. Calculation

$$\text{mg/l boron} = \frac{(A - B) \times 250}{\text{ml sample}}$$

in which A is milliliters of NaOH for the sample, and B is milliliters of NaOH for the blank.

6. Precision and Accuracy

This method is accurate to 5 μg boron.

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Proposed Standard Method for Total-Chromium Determination

Committee Report

A report made under the jurisdiction of Committee 8930 P—Standard Methods for the Examination of Water, Sewage and Industrial Wastes (Michael J. Taras, Chairman) by a group composed of Maxim Lieber, W. Allan Moore (Adviser), and Michael J. Taras.

The Standard Methods Committee of AWWA intends, from time to time, to present proposed methods for various constituents of water. These methods will be presented after appropriate subcommittee and committee consideration for eventual inclusion in the Eleventh Edition of Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. *The objective of this policy will be to encourage the broader use of the new methods with a view to learning their limitations. Comments, suggestions, and criticisms are invited on the proposed permanganate-azide method, as well as on all procedures in the Tenth Edition. Please address all pertinent remarks to the American Water Works Association, 2 Park Ave., New York 16, N.Y.*

Permanganate-Azide Method

Selection of method. The permanganate-azide method is recommended for the determination of total chromium in water samples containing organic material. It is the method of choice for the determination of total chromium in unknown samples. The alkaline hypobromite method is useful as a control method for total chromium in treated waters, but is not designed for samples containing an appreciable amount of organic matter.

1. General Discussion

1.1. *Principle.* The original hexavalent chromium in the sample is first reduced with sodium sulfite to the less volatile trivalent form. The sample is evaporated and fumed with acid to destroy the organic matter. The trivalent chromium is oxidized to the hexavalent condition by a slight excess of potassium permanganate. The chromium is reacted with diphenylcarbazide after the excess permanganate has been removed by means of sodium azide.

1.2. *Interference.* In the color development step, the following substances may cause interference:

Mercury, both mercurous and mercuric, gives a blue or violet-blue color, but the reaction is not very sensitive at the acidity employed. Iron in concentrations greater than 1 mg/l interferes by producing a yellow color with the reagent. Vanadium interferes in the same manner but more strongly. The color produced with vanadium fades fairly rapidly and is negligible 10 min after the addition of the diphenylcarbazide.

1.3. *Storage.* As chromate ions have a tendency to be adsorbed on the surface of the container and also may be reduced by various agents, precautions should be observed in sample collection and storage. New bottles rather than old etched containers should be used for sample collection. The sample should be tested during the day of collection if hexavalent chromium is to be determined. Storage for more than 2–3 days is not recommended.

2. Apparatus

2.1. *Acid-washed glassware.* New and unscratched glassware will minimize chromium adsorption on the glass surface during the oxidation procedure. Glassware previously treated with chromic acid, as well as new glassware, should be thoroughly cleaned with hydrochloric or nitric acid for removal of chromium traces, followed by the usual adequate rinses with tap and distilled water.

2.2. *Colorimetric equipment.* One of the following is required:

a. Spectrophotometer, for use at 540 mμ, providing a light path of 1–10 cm.

b. Filter photometer, providing a light path of 1–10 cm, and equipped with a green filter having maximum transmittance at 540 mμ.

3. Reagents

3.1. *Chromium-free distilled water.* Redistill from an all-glass apparatus if necessary.

3.2. *Sulfuric acid,* 18*N*, 1 + 1.

3.3. *Nitric acid,* concentrated.

3.4. *Sodium sulfite solution.* Dissolve 1.26 g Na_2SO_3 in distilled water and dilute to 100 ml. Prepare a fresh solution daily. One milliliter of this solution will reduce approximately 3.4 mg of hexavalent chromium to trivalent chromium.

3.5. *Potassium permanganate,* approximately 0.1*N*. Dissolve 0.632 g $KMnO_4$ in distilled water and dilute to 100 ml.

3.6. *Sodium azide solution.* Dissolve 0.5 g NaN_3 in distilled water and dilute to 100 ml.

3.7. *s-Diphenylcarbazide reagent.* Dissolve 0.2 g in 100 ml of 95 per cent ethyl alcohol; add, with mixing, an acid solution prepared from 40 ml concentrated H_2SO_4 and 360 ml distilled water. Kept under refrigeration, the solution is stable for about 1 month. Its color will change from colorless to tan without affecting its usefulness.

3.8. *Stock chromium solution.* Dissolve 0.141 g potassium dichromate, $K_2Cr_2O_7$, in distilled water and dilute to 1.0 liter. This solution contains 50 mg/l Cr.

3.9. *Working chromium solution.* Dilute 20.0 ml stock chromium solution to 1.0 liter. Each milliliter of this solution contains 0.001 mg hexavalent chromium. Prepare a fresh solution daily.

4. Procedure

4.1. Determine the sample size by a rough preliminary analysis. To the sample in an Erlenmeyer flask add 5 ml H_2SO_4 and 1 ml Na_2SO_3 solution. Allow to stand 10 min for complete reduction of hexavalent chromium. Add three glass beads or equivalent to control bumping, and cover the flask with a small funnel, which acts as a reflux condenser. (The use of three Berl saddles eliminates the need for the funnel.) Proceed to Sec. 4.3 unless the sample contains unusual organic levels which resist decomposition during sulfuric acid fuming.

4.2. If the sample contains high concentrations of organic material, such as sewage, add 5 ml concentrated HNO_3 and evaporate to fumes. To samples which are not water-white at this stage, add 10 ml H_2SO_4.

4.3. Evaporate to fumes and fume for 15 min or until clear. Cool and carefully dilute to about 50–80 ml. Bring to a boil and add sufficient $KMnO_4$ dropwise so that a faint pink color persists as the solution continues to boil for 10 min. Then add the NaN_3 solution dropwise and continue boiling until the solution becomes colorless. Boil for about 2 min between azide additions to guard against the use of excess azide. Cool the sample.

4.4. In the absence of suspended matter and color, transfer the sample to a 50-ml Nessler tube or volumetric flask.

4.5. Alternatively, remove any suspended matter by filtration through a sintered glass filter of coarse or medium porosity. Use a filter of coarse porosity for colorless samples. If MnO_2 precipitate is present, pass the sample through a filter of medium porosity under suction. Wash the filter well. Collect the filtrate in a 100-ml Nessler tube or volumetric flask to permit sufficient washing.

4.6. Add 2.5 ml diphenylcarbazide reagent and mix well. Compare visually against standards containing 0.003–0.20 mg/l Cr. Prepare a calibration curve in the chromium range of 0.005–0.40 mg/l (Beer's law is followed up to 0.2 mg/l) if photometric measurements are made at 540 mμ with a 5-cm light path. Make comparisons or readings at least 5 min, but not later than 15 min, after the reagent is added. Prepare the photometric curve from known amounts of chromium handled in the same manner as the unknown sample. Correct the results with a blank carried through all the steps of the procedure.

5. Precision and Accuracy

The average deviation approximates 10 per cent at 0.15 mg/l Cr. At lower chromium levels it may approach 20–40 per cent.

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Purposes and Policies of the Joint Committee on Uniformity of Methods of Water Examination

JCUMWE Statement

An official release of the Joint Committee on Uniformity of Methods of Water Examination, intended for publication by each of the member associations.

After several preliminary meetings in which the general organization and aims of a joint committee on uniformity of methods were discussed, this committee was officially organized at Biloxi, Miss., on Jan. 26, 1956. The charter members of the committee (JCUMWE) were eleven in number: the American Petroleum Institute, American Public Health Association, American Society of Mechanical Engineers, American Society for Testing Materials, American Water Works Association, Association of Official Agricultural Chemists, Federation of Sewage and Industrial Wastes Association, Manufacturing Chemists Association, Technical Association of the Pulp and Paper Industry, United States Public Health Service, and the United States Geological Survey. Within a short time after its organization, the group was joined by the United States Pharmacopoeial Convention.

The scope of the committee is the review of methods of water examination, published by member organizations, for the purpose of obtaining uniformity in sampling, testing, reporting test data, terminology, and application. Methods of water examination cover natural water, potable water, industrial water, industrial waste water, and sewage.

The committee's objective is to secure uniformity of methods by providing mechanisms for [1] exchanging information on projects in process, or contemplated, by the individual member organizations; [2] securing uniformity of terminology; and [3] reviewing methods and advising member organizations with respect to specific points. All the recommendations of this committee are advisory only and are not intended to supplant or to impede the work and publication policies of any participating interest.

Membership of JCUMWE is limited to [1] nonprofit organizations that (as a part of their functions) prepare, adopt, and publish, for general public distribution, water examination methods which are in general use; and [2] such other organizations as may be specifically invited by the committee to participate. On the basis of these requirements for membership, several applications for membership by local and regional organizations necessarily have been rejected. These denials of membership were made with misgivings because of the high esteem in

which the applicant organizations were held. Nevertheless, it has been held and adhered to that an organization such as JCUMWE can best function if it serves its purpose on a national or international scale rather than on a regional basis. This policy tends to keep the size of membership at a reasonable level and creates a relatively small, compact working group.

Procedure

The committee is bound by mutual agreement to meet at least once a year at a time and place agreed upon by a committee majority. Since its organization, however, it has been customary to meet twice a year.

At least once each year, every member organization is supposed to transmit in writing to all other members information on the status, scope, application, and principle of methods contemplated or in process. Not every member, however, has complied with this particular regulation. More universal adherence to this principle doubtless would expedite the work of JCUMWE.

Whenever practicable, at least 6 months before any new or revised method is submitted for final approval within his own organization, each member agreed to forward a copy of the then current draft of the method to all committee members and provide the committee secretary with sufficient copies to be used for possible review panel operations.

Any member organization of JCUMWE may submit a method for review. The only requirement for submission of a method is that it be in a form meeting the standard of the submitting organization and that 25 copies of the method, along with 25 copies of a survey form presenting pertinent facts relative to the method, are submitted to the committee secretary. Copies of this material are distributed to each member of JCUMWE, who then completes the survey form with respect to his own organization. If his organization publishes or intends to publish a comparable method, the responding member submits 25 copies of a second form and 25 copies of his organization's method.

Review Panel

The chairman of JCUMWE appoints a technically competent panel to review the material submitted. The members of the panel need not be members of JCUMWE, but must be people experienced in the specific field covered by the method being reviewed. Within 3 months of its appointment, the panel is asked to make recommendations to the committee on the elimination of inconsistencies between the material under review and other methods with the same or comparable purpose. In practice, this length of time has proved to be too short. Generally, more than 6 months has been required to complete this review.

The panel proceeds with a study of material thus distributed and attempts to reach an agreement on recommendations for standardization. When such agreement has been reached, the review panel prepares and submits to the JCUMWE secretary 25 copies of its recommendations. These recommendations are accompanied by the reasons for making them.

In the past and doubtless in the future, some individuals may consider the recommendations made by these

review panels to be rather harsh on certain member organizations in the criticism of methods published or to be published. It must be kept in mind, however, that each member organization of JCUMWE is pledged to cooperate in a common cause and with an open mind. Presumably, the representatives of these member organizations have been carefully selected with this thought in mind. Furthermore, it has been the responsibility of the chairman of JCUMWE to select panel membership in such a manner as to reflect not only the best in technical judgment, but the ultimate in unbiased and open-minded consideration. Thus, it is expected that not only will the recommendations of a given review panel be constructive, fair, and sincere, but also that the contributing organization will welcome any and all constructive criticism in an effort to reach the common goals of the joint committee.

The secretary of JCUMWE conducts a letter ballot of the committee membership on the panel's recommendations. Each member organization casts a single vote on the balloted recommendation and files this vote within 30 days with the secretary. Both affirmative and negative votes should be accompanied by the reasons for them.

The result of the voting and a second copy of the recommendations are sent to the originating member and to each member that has published or intends to publish a comparable method. The result of the voting only is transmitted to all other JCUMWE member organizations.

The result of this voting is interpreted to be a reflection of the joint opinion of JCUMWE. As such, each member organization is advised by its representatives and is asked to comply with the recommendations whenever possible. At all times, however, it must be kept in mind that the recommendations of JCUMWE are not mandatory but are *recommendations* only. The member organizations are not bound to follow these recommendations, but in the interests of uniformity are asked to do their utmost in complying with them. This action was necessary so as not to hinder the publication policies of the participating interests. It has never been intended that these publication policies should be interfered with or delayed. Each member organization is expected to report back to JCUMWE through its representatives as to whether the JCUMWE recommendations were acted upon and to what degree.

Subjects of Study

To date, review panels have been established on the following items:

1. Terminology and definitions
2. Reporting of results
3. Methods for acidity and alkalinity (basicity)
4. Methods for chemical oxygen demand
5. Methods for dissolved oxygen
6. Methods for hardness
7. Methods for settled, suspended, and dissolved matter (solids)
8. Methods for insoluble and dissolved iron
9. Methods for grease and oily matter
10. Methods for pH
11. Methods for organic nitrogen.

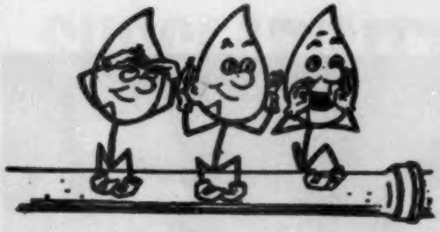
Recently, two other items have been introduced which require the establish-

ment of review panels. These are uniformity of reagents and methods for the determination of odor.

Recommendations have been submitted by the panels to the parent committee on: terminology and definitions, reporting of results, methods for hardness, methods for settled, suspended, and dissolved matter, methods for insoluble and dissolved iron, and methods for grease and oily matter. One of these reports has been returned to the review panel for further work. Another has been taken back by the review panel for continued deliberations. None of the reports has been officially released as a joint committee recommendation. It is believed, however, that one or two such recommendations will be forthcoming in the near future.

Conclusion

The harmony and agreement of thought that prevail in the operation of JCUMWE have opened the door to the establishment of close cooperation among the principal organizations that prepare, adopt, and publish (for general public distribution) water examination methods which are in general use. This is the answer to a problem that has plagued the laboratory man for many years. JCUMWE is an instrument whereby a test by one "standard method" will provide the same answer as the equivalent test by any other "standard method."



Percolation and Runoff

Do It Now! was AWWA's theme at Big D last Apr. 20–25—do your water works building now, not only to put public water systems in shape to provide "improved water service . . . adequate to meet the growing needs of each community," but to help counteract the current slowdown in the nation's economy. Thus, from Dallas's beautiful new Memorial Auditorium, where more than 3,000 members and guests signed in for AWWA's 78th annual meeting, there issued a constant stream of letters, wires, resolutions, telephone calls, radio and TV speeches, releases, and facts and figures, calling upon everyone, from President Eisenhower through 48 governors to the individual citizen, to help push the water works construction figure up from its present $400,000,000 per year to the $750,000,000 level required to catch up with war-postponed projects and to keep up with growing demands. And while the theme singers were busy with the why of "Do It Now!," 125 programers were telling how and, in 200 booths, 100 of AWWA's Associate Members were showing with what.

Actually, the how "do" and with what deserve special mention. Offering a comprehensive discussion of all the water works field's pressing problems, the technical program attracted S.R.O. crowds to most of its fourteen sessions. And such subjects as the emergency reuse of water at Chanute, Kan., AWWA's water works advancement program, the emergency control of main breaks, legislation on water rights, and the report on "water conditioning" devices kept the discussions going far, far into the Texas nights and even into the entertainment rooms. Meanwhile, in the exhibit area of the most beautiful auditorium in which AWWA has ever held a convention, a hundred Associate Members lived up to the surroundings in presenting what everyone agreed was the most beautiful exhibit ever held. Not just beautiful, however, the exhibit was convincing in showing how easy and what a pleasure it could be to "Do It Now!"

But Big D wasn't all "do"; there were doings, too—big doings that kept everyone busy during every unbusy minute of the week. And if the registration total (see statistics, P&R p. 48) didn't quite reach the record, there was certainly no evidence of that in the registration line on Sunday or at any of the functions. As a matter of fact, with everyone coming early and staying, there must have been more manhours of conventioneering, if not more men, than ever before. The fun that started on Sunday at 6, when more than 500 buffeted before an evening of meeting and greeting, kept going morn-

(*Continued on page 36 P&R*)

(Continued from page 35 P&R)

'Do It Now' is promoted on radio and TV at Dallas—top: Johnny Harper (left), on his KRLD-CBS radio show (Monday, Apr. 21), interviews Carr Forrest, Dallas consulting engineer, W. W. Lynch, Texas Power & Light Co. president, and John Murdoch, AWWA consultant on the water works advancement program; bottom: Don Norman (Feature Theatre, WFAA-TV, Tuesday, Apr. 22) interviews AWWA Presidents Merryfield and Finch.

(Continued on page 38 P&R)

(*Continued from page 36 P&R*)

ing, noon, and night through the week. Thus, on Monday there was a full house on hand to honor AWWA's Men of the Year:

HONORARY MEMBERS: M. B. Cunningham, V. M. Ehlers, F. G. Gordon, L. F. Warrick.
DIVEN MEDAL: R. L. Derby.
GOODELL PRIZE: H. O. Hartung.
DIVISION AWARDS: J. B. Wolff (Distribution), H. H. Gerstein (Management), Graham Walton (Purification), H. O. Banks (Resources).
FULLER AWARDS: C. H. Bagwell, T. J. Blair Jr., C. W. Brinck, H. H. Caswell, G. H. Dyer, A. G. Fiedler, R. H. Fuller, W. H. Gilmore, Jack Gordon, P. D. Haney, P. J. Houser, E. C. Hubbard, D. W. Johnson, J. C. Knox, J. W. Kruse, H. N. Lowe Jr., Q. M. Mees, M. S. Nichols, W. J. Orchard, Harry Reinhardt, W. F. Rockwell, G. J. Schroepfer, L. R. Simonton, L. B. Smith, G. H. Strickland, S. W. Wells, G. H. West.
JORDAN SCHOLARSHIP: J. D. Goff.

to cheer the first two winners of the Wendell R. LaDue Safety Award:

CLASS 2: Duluth, Minn. (M. D. Lubratovich, General Manager).
CLASS 3: East Bay Municipal Utility District, Oakland, Calif. (A. J. Webb, Safety Director).

to salute AWWA's past-presidents as they received certificates of appreciation, and finally to dance. Then, on Tuesday, after Bill Stokes of Hendersonville, N.C., among the operators, Earl Hodges of Sparling Meter Co., among the manufacturers, and Mrs. Tom (James B. Clow & Sons) Egan, among the ladies, had led the golfers around the championship Preston Hollow Country Club course, an enthusiastic 2,000 made the seams of the Auditorium theater bulge, as well as the beams reverberate, during an evening of music, mimicry, and magic that will long be remembered. And finally, on Thursday, almost 1,300 were on hand at the annual dinner to salute Passing President Fred Merryfield; to cheer the Iowa Section as it was awarded the Hill Cup; the Pacific-Northwest Section, the Henshaw Cup; and the California Section, the Old Oaken Bucket; to welcome Incoming President Lew Finch; and then, again, to dance.

"Do It Now" not only was the theme of the week, but had obviously long been the theme of the convention committees headed up by Henry and Alice Graeser. With first lieutenants Karl Hoefle, R. E. Morris, Charlie Clinger, and Bill Hoffman and a hundred or more second lieutenants, Henry had made the convention priority business for so many months that he probably needed the flood which immediately followed to fill the gap in his schedule. Just so are two other workers relatively relaxing now that it is over—Bob Gresham, whose publicity hours and efforts knew no bounds, and Sig Sigworth, whose Big D Tours kept him jumping for months. Meanwhile, another Graeser who did a lot of doing was Alice, who, with the Missuses R. B. Allen, K. F. Hoefle, R. E. Morris, and W. E. Pebworth, played hostess to the mostes' AWWA ladies ever and drew not only the largest crowds but the biggest compliments for the tea, card party, luncheon, and—from the ladies anyway—for the Nieman-Marcus style show that kept them busy during "working" hours.

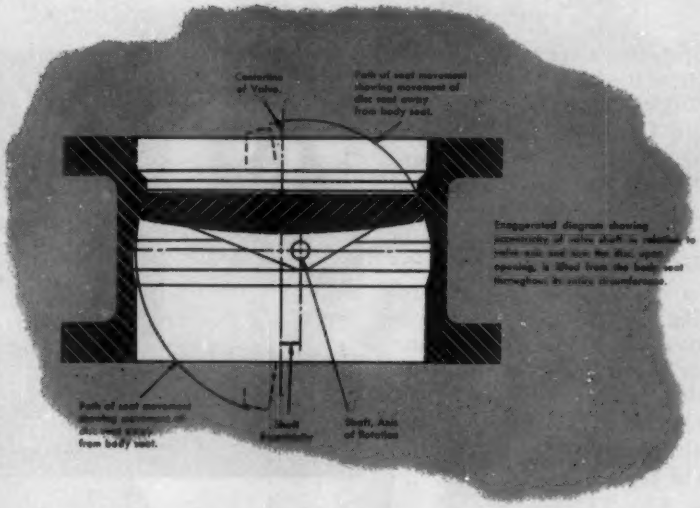
Big D may not have registered the most, but it was the "most" and it will take some mighty Big Doing to outdo it. Big as all outdoors, we hear, are Californians, and, with more than a year to get ready, they promise it *will* be done, next Jul. 12–17 in San Francisco! Help do it then!

(*Continued on page 40 P&R*)

(Continued from page 38 P&R)

Left—President Merryfield congratulates James D. Goff on receiving the Harry E. Jordan Scholarship Award, as Secretary Jordan looks on. Below—Presidents Finch and Merryfield get the Canadian viewpoint in conversation with Fuller Awardee G. Hudson Strickland and Canadian Section Director Russell Armstrong.

(Continued on page 42 P&R)



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(*Continued from page 40 P&R*)

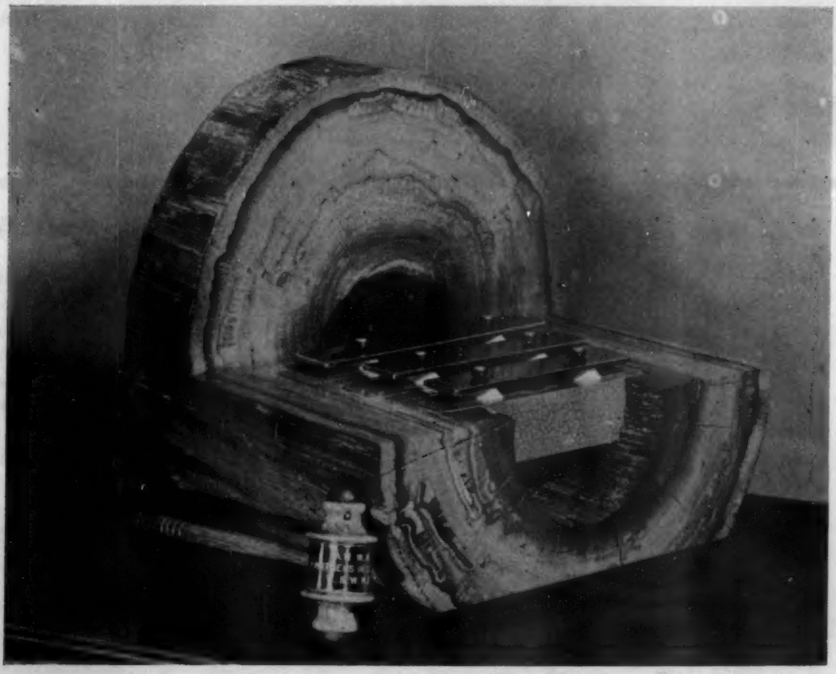
A World Premiere, no less, was one feature of the Big D program, presenting Willing Water as a film star. The film, a 15-minute sound slidefilm in color, tells *The Story of Water Supply.* Following the basic outline and text of the picture book of the same title, the film is suitable for use in schools and before civic clubs. As the sound and film strip are synchronized, they can be projected automatically as a continuous illustrated talk on water supply, or, by manual operation, the presentation can be interrupted to fill in local details orally. The film, complete with record, is being sold by AWWA at $35 per copy.

(*Continued on page 44 P&R*)

(*Continued from page 42 P&R*)

Premiered, also, at Dallas was the performance of a set of chimes (see cut) presented to AWWA by the Water & Sewage Works Manufacturers Assn. as an anniversary gift. Actually, the anniversary is WSWMA's —its 50th—but the chimes, made from a section of a white oak water main installed in the streets of Philadelphia sometime between 1800 and 1820, are AWWA's, to be used in calling its meetings to order. The idea of using the log for an AWWA present was conceived by Dick Ford of Ford Meter Box Co., president of WSWMA, but it was Harry Schlenz of Pacific Flush Tank Co., WSWMA past-president, who took over the log and put it to music with the help of J. C. Deagan, Inc., prominent carillon and marimba manufacturers. Presented to AWWA President Fred Merryfield at the opening session of the Dallas meeting by Harry Schlenz, the chimes and accompanying gavel (on which is inscribed "AWWA—WSWMA—Partners in Service") were used also in the ceremonies at the annual dinner.

Eauhieau is the way they're spelling the name of the Buckeye State these days, now that municipal water plants have become the second biggest source of municipal income. The "hi," of course, represents property taxes—the "biggest" source. This must be a sign, though, that the 109/143 of Ohio cities which operate their own water works are finally beginning to realize their rates. It can't be only thirst!



(*Continued on page 82 P&R*)


"Mister---
what's
inside
besides
water?"

1958 CONFERENCE STATISTICS

(See story on p. 35 P&R)

Dallas Registration by Days

Day	Men	Ladies	Total
Sunday, Apr. 20	1,315	450	1,765
Monday, Apr. 21	812	220	1,032
Tuesday, Apr. 22	137	17	154
Wednesday, Apr. 23	61	—	61
Thursday, Apr. 24	12	—	12
TOTALS	**2,337**	**687**	**3,024**

Geographic Distribution of Registrants

UNITED STATES & TERRITORIES

Alabama	42
Arizona	18
Arkansas	79
California	161
Colorado	38
Connecticut	23
Delaware	11
Dist. Columbia	16
Florida	43
Georgia	48
Hawaii	1
Illinois	171
Indiana	94
Iowa	58
Kansas	65
Kentucky	32
Louisiana	92
Maine	4
Maryland	25
Massachusetts	29
Michigan	79
Minnesota	33
Mississippi	29
Missouri	99
Montana	9
Nebraska	20
New Hampshire	2
New Jersey	119
New Mexico	11
New York	184
North Carolina	28
North Dakota	8
Ohio	121
Oklahoma	73
Oregon	9
Pennsylvania	168
Puerto Rico	2
Rhode Island	16
South Carolina	23
South Dakota	9
Tennessee	60
Texas	620
Utah	4
Virginia	25
Washington	21
West Virginia	23
Wisconsin	78
Wyoming	2

CANADA

Brit. Columbia	1
Manitoba	1
Ontario	79

FOREIGN

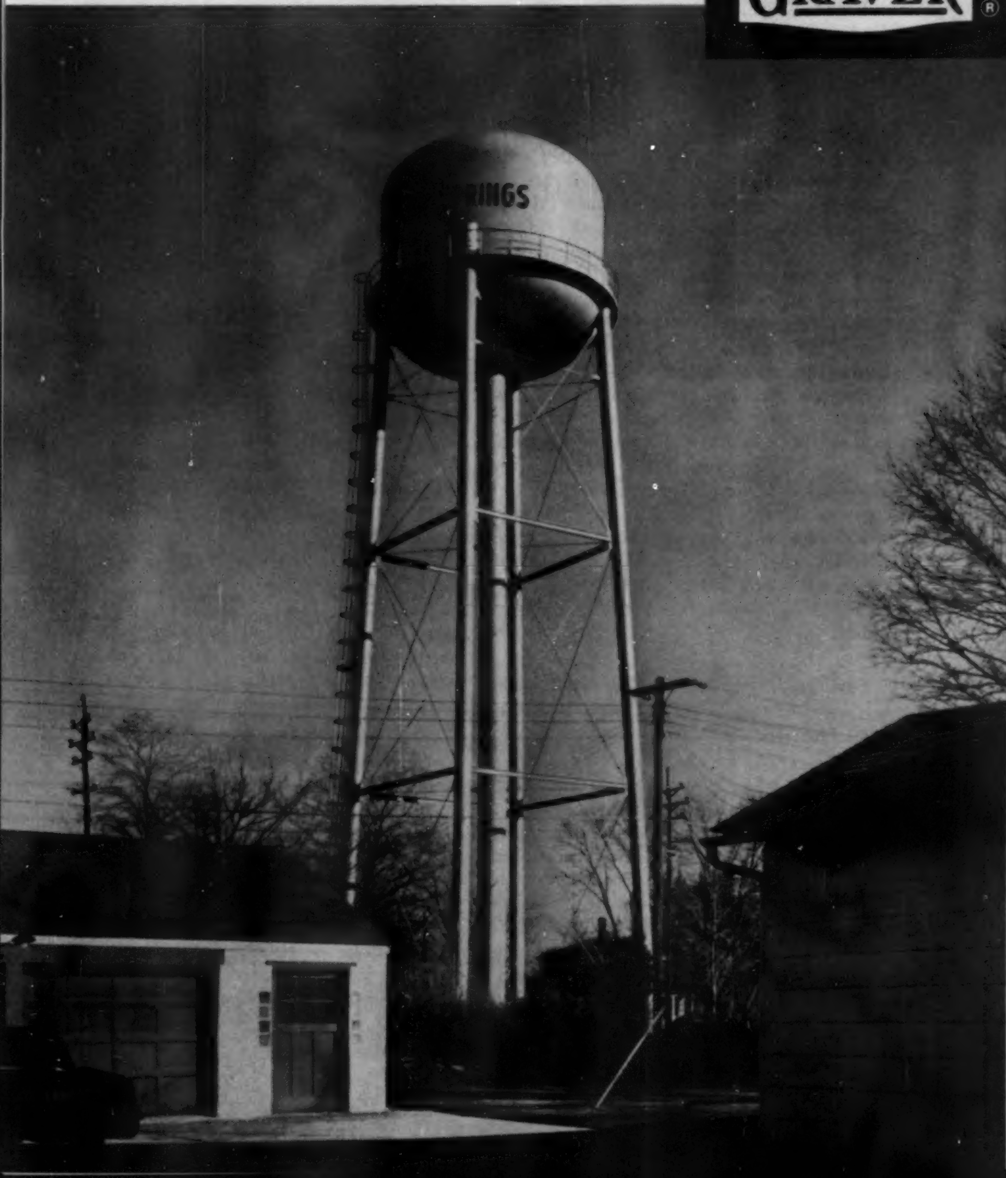
Asia	1
Europe	8
Latin America	9
TOTAL	**3,024**

Comparative Registration Totals—1949–1958

Year	Place	Men	Ladies	Total
1958	Dallas	2,337	687	3,024
1957	Atlantic City	2,398	669	3,067
1956	St. Louis	2,026	510	2,536
1955	Chicago	2,075	512	2,587
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967

Win, Place & Show in Section Awards

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Pacific Northwest	**70.6%**	**Iowa**	**30.26**	**California**	**1,424**
Rocky Mountain	64.1%	Rocky Mountain	27.50	Southwest	1,031
Arizona	59.5%	Ky.-Tenn.	19.20	New York	866


RINGS

The Reading Meter

Plant Engineering Practice. *F. W. Dodge Corp., 119 W. 40th St., New York 18, N.Y. (1958) 704 pp.; $18.50*

Practical solutions to many of the problems commonly encountered in plant engineering are offered in this large, handsomely designed, and well illustrated volume consisting of more than 200 articles covering such subjects as sites and layout, construction, housekeeping and safety, materials handling, maintenance, power and piping, lighting, heating and ventilating, and shopwork. The material in the book was selected from the magazine, *Plant Engineering,* with the object of providing authoritative, up-to-date information that will remain useful for years. The compilation is not intended as a textbook or handbook but as a source of ideas and procedures for dealing with a variety of situations and conditions occurring in all types of plants. Water works men will find it a useful reference whether they are designing an entire treatment plant from scratch or merely trying to determine the best way to light a meter shop.

Sewage Treatment. *Karl Imhoff & Gordon M. Fair. John Wiley & Sons, Inc., 440—4th Ave., New York 16, N.Y. (2nd ed., 1956) 338 pp.; $7.50*

This second edition of a book first published in 1940 has been entirely rewritten to cover important recent developments in the field; sections on a few procedures that have proved uneconomical have been eliminated. The objective of the book is to present simply and concisely the practices and requirements of modern sewage treatment. As in the preceding edition, advanced mathematical formulations and elaborate drawings are avoided. The general nature of the structures and mechanisms commonly used in sewage treatment is outlined as clearly as possible in the text and the illustrations.

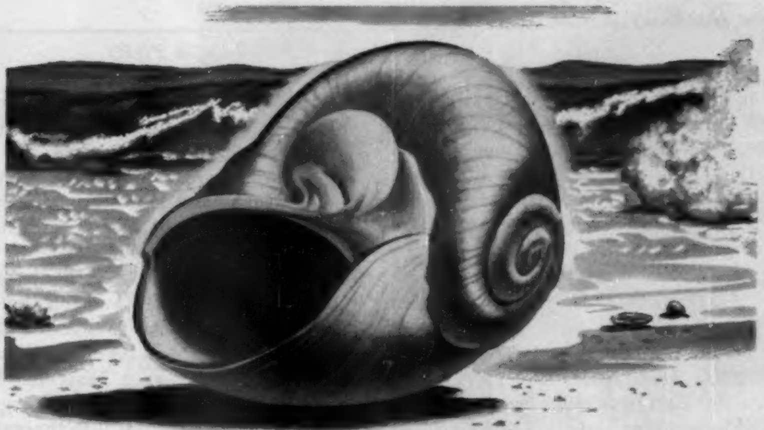
Bibliography of Solid Adsorbents, 1943 to 1953. *Victor R. Deitz. Circular 566, National Bureau of Standards (1956) 1,528 pp.; $8.75 (order from US Government Printing Office, Washington 25, D.C.)*

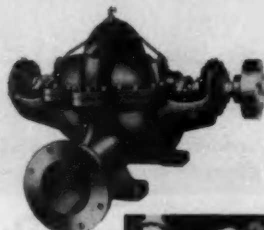
Over 13,000 articles on solid adsorbents published in world scientific literature during 1943–53 are cataloged in this large volume, with a brief summary of each. The water and sewage section contains more than 400 articles. An excellent subject index, as well as an author index, is provided. This volume complements an earlier bibliography for the years 1900–42.

Data Book for Civil Engineers. II. Specifications and Costs. *Elwyn E. Seelye. John Wiley & Sons, Inc., 440—4th Ave., New York 16, N.Y. (3rd ed., 1957) 550 pp.; $20*

This revision of Volume II of the *Data Book* series is intended to provide more nearly up-to-date cost information than the earlier (1951) edition. Some changes in specifications are also included in the new edition. Unfortunately, the references to AWWA standards which were out of date in the second edition (as pointed out in the February 1952 Reading Meter, p. 16 P&R) are still out of date. The compiler of such a great variety of material from so many sources is faced with a difficult problem, but it would

(Continued on page 52 P&R)





The Reading Meter

(*Continued from page 50 P&R*)

seem that the purpose of successive editions is to overcome the defects of earlier ones. Although the water supply specifications in the new edition cannot be recommended as completely reliable, the book and its companion volumes remain a useful reference for the specialist on the occasions when he must deal with engineering matters outside his particular field.

NFPA Standards: No. 12—Carbon Dioxide Extinguishing Systems; No. 30—Flammable Liquids Code; No. 31—Installation of Oil Burning Equipment. *National Fire Protection Assn., 60 Batterymarch St., Boston 10, Mass. (each 64 pp., paperbound, published 1957); No. 12, $0.75; No. 30, $0.60; No. 31, $0.60*

NFPA No. 12 is a revision of a previous standard covering the use of carbon dioxide extinguishing systems for the protection of gaseous and liquid flammable materials, hazardous solids, and ordinary combustibles in special enclosures, as well as other types of hazards. NFPA No. 30 deals with all phases of the storage and handling of flammable liquids. It supplants the former "Suggested Ordinance on Flammable Liquids" and is intended to be used as a basis for both municipal ordinances and state regulations. NFPA No. 31, incorporating more than 50 changes from the 1956 edition, covers the regulation of all types of oil-burning equipment, formerly the subject of several separate documents. The revised standard is suitable for use as the basis of a municipal ordinance.

Professional Services

Professional Services

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Professional Services

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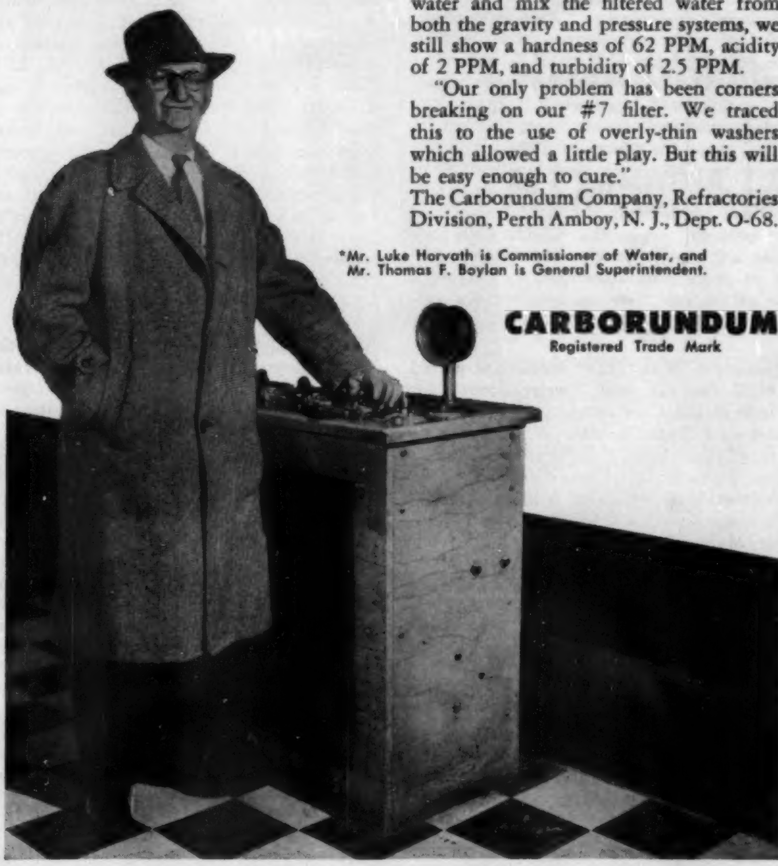

Condensation

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BACTERIOLOGY

The *Coli-aerogenes* Picture of Drinking Water in Different Stages of the Process of its Purification. N. D. Rurshtein & T. S. Piasetskaya. J. Microbiol. (Moscow), **9**:97 ('55). Of 206 coliform bacteria isolated from drinking water, 57% were *coli commune*, 26% were *coli citrovorus*, and 17% were *coli-aerogenes*. After first application of chlorine, citronegative bacteria were reduced from 81% to 21% and, after second application of chlorine, these organisms disappeared completely. *Bact. coli* which assimilated citrate were present in original water in concn. of 19%. This increased to 42% after first application of chlorine and to 100% after second, with *coli-aerogenes* predominating. It is suggested that coliform organisms which assimilate citrate are able to survive chlorination, and that in process of adaptation to effects of chlorination, *coli commune* acquired new cultural characteristics.—*WPA*

Experiences With Three Media Incubated at 44°C for Six and Twenty-four-Hour Periods in the Confirmatory Test for *Bacterium coli* Type 1. N. W. Simpson & H. G. Coles. Proc. Soc. Water Treatment Exam. **5**:183 ('56). Comparison was made of incubation at 44°C for 6 hr and for 24 hr in confirmatory test for *Bact. coli* Type 1, using MacConkey broth, BGB, and fortified peptone water. Results, given in tables, show that high percentage of positives obtained in all 3 media after incubation for 24 hr was also obtained after shorter incubation period of 6 hr. For types of water samples used, BGB was slightly better than MacConkey broth for 6-hr incubation period, while indole test appeared to be better than either of other 2 for rapid confirmation of *Bact. coli*. Number of false positive results was very small, majority of them being obtained in first 6 hr.—*WPA*

Pigmented Strains of *Coli-aerogenes* Bacteria. S. B. Thomas & K. Elson. J. Appl. Bacteriol., **20**:50 ('57). Although chromogenesis is not common property of *coli-aerogenes* bacteria, pigmented strains have been described by several investigators. Authors investigated 52 strains of *coli-aerogenes* bacteria, isolated at 30°C from soil, water, grass, cereals, and milk, which formed yellow, orange, or reddish-orange pigment on Yeastrel milk agar in 14 days at 22°C. Table is given showing these pigmented bacteria arranged in 3 groups, according to whether or not acid and gas were formed from lactose at 37°C and 30°C. It appeared that formation of pigment is not confined to any genus or species of bacteria studied, and that it has, therefore, no taxonomic value. Only 11% of pigmented cultures were 37°C positive and majority (60%) were anaerogenic or paracolon strains of *Citrobacter* and *Klebsiella*.—*WPA*

A Proposal for Simplification of Routine Bacteriological Examination of Water. D. Haller. Z. Hyg. Infektkrankh. (Ger.), **143**:599 ('57). Author describes method for detg. total bact. and coliform counts in water, using membrane filters and Schriek's saccharose Endo agar. Portions of 1, 10, and 100 ml of same sample are filtered through separate membrane filters in turn, using same funnel without cleaning. 3 membrane filters are placed on 1 large Endo plate and incubated for 24 hr at 37°C. Comparisons showed that gelatin pour plate method was less reliable and did not give higher numbers than method described. Coliform colonies were examined by Vüllers' method, using Kligler tubes. For indole formation, use of SIM nutrient medium is recommended. Modification of Daranyi's process for distinguishing *Bact. coli* from warm blooded animals and from cold blooded animals is described.—*WPA*

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New Methods of Water Examination. K. SCHILLING. Vom Wasser (Ger.), **23**:24 ('56). Author discusses importance of examn. of water in field and equip. of mobile labs. and gives account of use of "bactostrip" method of bact. anal., in which paper strip of known size and absorption capac., impregnated with suitable culture medium, is used. Comparison of this method with usual culture methods by numbers of investigators is described.—*WPA*

Desensitization of *Escherichia coli* to Ultraviolet Light. R. S. WEATHERWAX. J. Bacteriol., **72**:124 ('56). Working with parent strain of *Escherichia coli* B of radiation-resistant mutant strain B/r of *Esch. coli*, expts. were conducted in which suspensions of bacteria in mineral salts medium were first exposed to visible light for 0, 1.5, 2.5, and 4 min before irradiation with ultraviolet light. From ultraviolet light-survival curves for different visible light exposures, it can be seen that *Esch. coli* strain B can be desensitized to ultraviolet light by prior exposure to visible light, bacteria receiving increasing protection from lower doses of ultraviolet light, up to 80-sec exposure, with increasing duration of preliminary illumination.—*WPA*

The Use of the Membrane Filter Technique for Testing Water Supplies in the field. M. C. HOPE & A. H. NEILL. Pub. Health Repts., **71**:1093 ('56). Feasibility of using membrane filter (MF) field test lab. to det. bact. qual. of drinking water supplies in national parks, was evaluated. In addn., sanitary surveys of water supplies, sampled for examn. by MF kit, were made, which included inspections of collection, treatment and distr. systems of each water supply, and study of drainage areas. Findings show 86% agreement in results obtained by MF technique and standard diln. tube test. Results of MF tests are available in less than 1 day and can be applied directly to evaluation of individual water supplies. Satisfactory results were obtained when portable testing kit was set up in central shelter within parks where samples were brought for anal. Operation of kit was found to be simple and rapid; however, specialized training and familiarity with equip. is necessary. Studies indicated that MF method can be used for bact. examn. of isolated water supplies as found in national parks, and showed need for improvement in portable field labs. (MF kits), particularly in method of incubation.—*PHEA*

The Membrane Filter Method in the Detection of Sulfite-Reducing Clostridia in Water and Other Fluids. J. PAPAVASSILIOU & K. H. WEGENER. Zentr. Bakteriol. (Ger.), **167**:5:383 ('57). Membrane filter (produced by Sartorius works under description M.I. 5) is used to filter considerable quants. of water—100–200 ml—and membrane is then transferred with usual precautions for sterility to plate covered with thin layer of nutrient agar. When this has been applied to agar in base of plate, 20 ml of 2% glucose nutrient agar to which sodium sulfite in proportion of 2% and 5 drops of an 8% soln. of pure ferrous sulfate have been added, are poured over it. Finally, third layer of nutrient agar is poured on top of second layer to ensure anaerobic conditions in intermediate glucose-agar. Clostridial colonies are recognized as black patches. Method is recommended for picking up such bacteria when present in small numbers in contamd. water. It is recommended that water should be heated at 75°C in water bath for 5–7 min and then cooled before filtering.—*BH*

Comparison of Fermentation Tube and Membrane Filter Techniques for Estimating Coliform Densities in Sea Water. I. Preliminary Report. R. M. CONNER. Appl. Microbiol. **5**:3:141 ('57). This is prelim. report on comparing membrane filter (MF) method and multiple tube method for estg. coliform organisms in sea water where shellfish are being cultivated. Results suggest that MF technique is less variable than 3-tube MPN method. Former method is more economical in time, effort, and materials. It is evident, however, that medium for use with MF requires modification to improve its selectivity for coliform organisms.—*BH*

The Enumeration of Waterborne Bacteria by a New Direct-Count Method. V. G. COLLINS & C. KIPLING. J. Appl. Bacteriol. **20**:2:257 ('57). Direct method has been devised to enumerate bacteria in lake water by means of concn. technique. Method involves staining of vol. of water sample of

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order of 0.01 ml with gentian violet dissolved in glycerol-base. Stained drop of water is concn. by evapn. in vacuum desiccator. Residue remaining after concn., consisting of glycerol and stained bacteria, is drawn into flattened glass capillaries and vol. of contents is detd. Actual direct count is carried out on this residue with microscope fitted with oil immersion objective lens. Results by direct count were 6 times to 11,000 times greater than by conventional colony count methods. Results were obtainable in 2 hr by direct-count method, whereas 10 days were required to obtain colony count on solid media. This method should be valuable help to limnologists since external factors affecting any body of water are constantly changing and rapid ests. of total bact. pops. will provide addnl. useful data. —*BH*

Comparative Tests of Certain Media Proposed for the Determination of Coliform Organisms in Water. G. GABBRIELLI & G. GIUNTI. Nuovi Ann. Igiene e Microbiol., **8**:5:525 ('57). Authors first point out that owing to multiplicity of methods for detection of coliform organisms in water, European regional office of WHO has suggested comparative tests between lactose, MacConkey, and lauryl sulfate broths, glutamic acid medium, and phenol peptone water. They, therefore, decided to compare first 3 media by 3 different sets of tests: [1] 10 samples of water. 10 cc of water were placed in each of 10 tubes of 3 media and incubated for 48 hr at 37°C. Tubes showing gas were presumed positive, confirmation was by 2% BGB (incubation for 48 hr at 37°C). Selectivity was estimated by "confirmed/presumed positive," and sensitivity by "confirmed/tubes inoculated." Lauryl sulfate medium was best, while MacConkey was more selective and less sensitive than lactose broth. [2] 5 different samples tested by multiple-tube method with estn. of MPN, confirming medium being same as before. Here lauryl sulfate and MacConkey were equal in selectivity but lauryl sulfate was most sensitive, with lactose next. [3]

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1 sample to test sensitivity especially. 500 cc were used for each medium. Here MacConkey was slightly more selective but lauryl sulfate more sensitive, with lactose next. Authors then work out statistical probability of results being due to chance. From this they state that there is no probability that MacConkey will give results equal to those by lauryl sulfate, that chances are less than 5% that lactose broth will give results equal to MacConkey, and that there is less than 5% chance that lauryl sulfate medium will give results equal to those with lactose broth only. Authors therefore do not consider MacConkey broth suitable medium for presumptive tests and recommend use of lauryl sulfate broth.—*BH*

***Pseudomonas aeruginosa* in Drinking Water.** R. Reitler & R. Seligmann. J. Appl. Bacteriol., **20**:2:145 ('57). Literature concerning antagonism between *Pseudomonas aeruginosa* (*pyocyanea*) and *Esch. coli,* natural habitat of former and its potential pathogenicity, is briefly surveyed by authors who state that *Ps. pyocyanea* is apparently more often found in tropical and subtropical waters than in those of temperate zones. These workers report presence of *Ps. pyocyanea* in over 12% of specimens of infected urine and in 10% of specimens of pus examined in Government Hospital Laboratory, Haifa. They also isolated organism from stools of 10% of series of healthy persons. *Ps. pyocyanea* was found to be antagonistic to *Esch. coli* in grossly pold. water, but both organisms could coexist in purified water. They conclude that isolation of *Ps. pyocyanea* from water must, therefore, at least raise suspicion of faecal contamn. and they put question as to whether water contmd. with *Ps. pyocyanea* should be declared as unfit for drinking in absence of significant numbers of *Esch. coli.* 1,000 water samples were also examd. by authors from northern district of Israel and in 41 instances they obtained counts of *Ps. cyocyanea* greater than 10 per 100 ml when corresponding *Esch. coli* content was nil and in 25 instances when *Esch. coli* content was less than 10 per 100 ml. It is concluded that *Ps. pyocyanea* should be taken into account as well as *coli-aerogenes* bacteria in assessing suitability of water for drinking purposes.—*BH*

***Salmonella* in Water.** G. Weber. Zentr. Bakteriol., **163**:312 ('57). Report of paper presented at meeting of Osterreichische Gesellschaft für Mikrobiologie und Hygiene in Sep. 1956. Expts. are described on viability of *Salmonella* in water supplies and surface waters used, after treatment, for supply. Solid nutrient media used in combination with membrane filters were found more suitable than liquid enrichment media. Especially suitable was bismuth-sulfite agar of Wilson and Blair. Results with Endo agar were unsatisfactory, one reason being that inhibiting action on other water bacteria was too slight. *Salmonella* were found to be detectable in water supplies for long periods, *S. paratyphi* B being more resistant than *S. typhi.* Former was detected in one expt. after 3 mo. After prelim. rapid decrease, death curve then showed flat section showing that under certain conditions constant state is reached. Viability of *Salmonella* is dependent both on condition of water and on temp. In some instances *Salmonella* were detectable for longer periods at 4° than at 22°C.—*WPA*

BOILERS AND FEEDWATER

The Application of Sea Water for the Feeding of Steam Boilers and Evaporators. I. Z. Makinskii. Azerbaidzhan. Neftyanoe Khoz. (USSR), **35**:11:35 ('56). It is economically feasible to run such equipt. with sea water if CaO only is used for H_2O softening. $CaSO_4$ and $Mg(OH)_2$ are pptd. In low-pressure boilers, NaCl and Na_2SO_4 do not cause noticeable corrosion. Qual. of steam is presented in tables.—*CA*

Foaming of Boiler Water. B. P. Tatarinov. Trudy Novocherkassk. Politekh. Inst., **25**:67 ('55). Foam-forming conditions in exptl. boiler with evapn. rate of 6.8–134 cu m/sq m/hr and heat transfer on heating surface 1860–37,200 kg-cal/sq m/hr are studied. Expts. are performed at 1 atm. pressure, and height of foam layer is observed visually. It is established that at const. loading of boiler, height of foam rises with salt content (up to 20 g/kg) of boiler water. Effect of salts (NaCl, $NaSO_4$, Na_2CO_3) differs; $NaCO_3$ has greatest effect. Effect of added substances appears when their concn. increases to 200 mg/kg. Basic factor

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affecting foam layer height is vol. load of surface of evapn.—*CA*

An Experiment to Adapt a Boiler for Increased Salt Content in the Feed. A. V. Chetverikov & S. I. Livshits. Teploenergetika (USSR), 4:6:25 ('57). Boiler to be reconstructed is designated as type TP-230-2 and it was desired to try to modify it to have 3-stage evapn. as follows: For first stage—158.5 tons per hr or 69% of whole; 49.5 tons per hr or 21.5% for second stage; and 22 tons per hr or 9.5% for third stage—a distr. which is very near to official specification for cascade scheme to use 3-stage evapn. When feed contains, resp., 50, 100, and 150 mg/l of salts and 1% of total is being discharged by cyclone at end of third stage, salt content in first stage is 178 mg/l, 481 mg/l in second stage, and 5,050 mg/l in third stage. Under same conditions, except that 5% of feed is discharged, corresponding figures are 159, 362, and 1,050 mg/l. When 150 mg/l was in feed and 1% was in discharge, corresponding salt contents were 535, 1,442, and 15,150 mg/l; at 5% steady discharge, 475, 1,085, and 3,150 mg/l. On basis of success of project, several plants are rebuilding their boilers accordingly.—*CA*

Safe Regimes for Alkaline Boiler Waters. P. A. Akolzin; D. Ya. Kagan, & A. A. Kot. Teploenergetika (USSR), 4:6:32 ('57). Drum-type boilers are subject to intercryst. corrosion by caustic alkali acting on strained parts of metal. Among ways of countering such action is to establish purely "phosphate alky."—that is, addn. of Na_3PO_4 which hydrolyzes to give Na_2HPO_4 + NaOH. For boiler without stages of evapn., excess phosphate concn. should be maintained at no higher than 40 mg/l calcd. at PO_4^{---} and min. alky. no. of about 9 mg/l NaOH. For boilers with stages of evapn., anal. (of alky. and phosphate concn.) should be made on last stage and should show max. of order of 100 mg/l phosphates, calcd. as PO_4^{---}, and min. concn. in boiler of about 5-7 mg/l with

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water tinged by phenolphthalein. This regime is unrealizable with treated (purified) water as feed; under such conditions sulfate regime ($Na_2SO_4 + NaCl$) per excess alky. $\geqq 5$, gives satisfactory results. This sulfate regime is applied also in case it is necessary to reduce amt. of silicic acid carried in steam. —*CA*

Hydrazine Supplements Sodium Sulfate. S. F. Whirl. Elect. Light and Power, **35**:89 ('57). 2-yr experience with N_2H_4 as O scavenger in boiler water for generating plant is discussed. Dosages of 0.008 ppm are considered adequate. ASTM D-1385 method —colorimetric by using *p*-dimethylaminobenzaldehyde (I)—was modified to use 100-ml sample, with half specified amt. of I being used and no N blanket. NH_3 and morpholine are used to control pH.—*CA*

The Ammonia–Carbon Dioxide–Water Equilibrium in Boiler Feedwater Conditioning. C. D. Weir. J. Appl. Chem. (London), **7**:505 ('57). NH_3 formed by dissocn. of NH_4 salts under boiler conditions can be used to neutralize CO_2 in steam condensate. Charts to det. NH_4 salt dosages are given.—*CA*

How Gulf Purifies Its Boiler Water. F. L. Resen. Oil Gas J., **55**:6:106 ('57). At Gulf Oil's Port Arthur, Tex., refinery, feed water for high-pressure boilers is demineralized before use. Cations and anions are removed in successive steps with sulfonated styrene ion-exchange resin and highly basic quaternary amine polystyrene ion-exchange resin, resp. Plant capac. is 1,800 gal/min. Water supply includes both salt and fresh water in ratio of 1,600 to 181 parts by vol. After demineralization, O is removed by deaeration to prevent corrision.—*CA*

Observations of Fe_3O_4-H_2O-O_2 Systems of Steam Boilers. R. Freier & H. Kiekenberg. Mitt. Ver. Grosskesselbesitzer (Ger.), **50**:329 ('57). What may take place in high-pressure steam boilers at various temps. and pressure is discussed. It has been observed that no reduction of protective coating of Fe_3O_4 takes place below 570° in absence of H_2 or at 510° and 187 atms.—*CA*

The Boiler Scale in Steam Boilers. P. T. Dunaev. Sakharnaya Prom. (USSR), **31**:5:46 ('57). Boiler scale of many boilers of Soviet sugar industry were analyzed for CaO, MgO, SiO_2, Al_2O_3, SO_3, P_2O_5, and Fe_2O_3 brought about by scale as corrosion product and volatile matter (H_2O and CO_2) contained in such scale.—*CA*

Hydrazine for Degassing Feed Water for High-Pressure Boilers. A. Gubin & W. Hoffmann. Mitt. Ver. Grosskesselbesitzer (Ger.), **50**:334 ('57). Review, 16 references.—*CA*

Demineralization of Boiler Water With Calcium. J. Sramek. Mitt. Ver. Grosskesselbesitzer (USSR), **49**:275 ('57). Use of lime is recommended for demineralization of water intended for boiler use, advantages being low content of SiO_2 (0.3–0.4 mg/l) and org. matter; complete removal of Mg, Fe, Mn, and HCO_3^-; and reduction of CO_3^{--} hardness to extent of $CaCO_3$ soly. Ion-exchange demineralization can be used to supplement process, if desired. Typical installation includes preheater capable of heating to 80°–85°, deaerator, lime addn. chamber with facilities for ppt. removal, filter, satn. chamber in which CO_2 gas is added (flue gas is a convenient source) equipped for ppt. removal, and any further filters or ion exchangers required. It is recommended that corrosion-resistant materials be employed in equipt. constr., and that pH of soln. through which a CO_2-contg. gas is passed not be allowed to drop below 9; prepurification of flue gas may be necessary. Pptd. $CaCO_3$ meets Merck specifications if pptn. conditions are properly controlled. Cost of water treatment by this method is estd. at about 0.35 marks per ton of treated water. This is sum of estd. costs for lime, electricity, service, repairs, maintenance, and heating with amortization over a period of 20 yr being figured.—*CA*

CORROSION

Corrosive Action of Water. E. Giménez San Martin. Dyna (Sp.), **32**:208 ('57). H_2O is classified according to pH; carbonate and total hardness; free, semicombined, and combined CO_2 content; O content; anion concn.; Fe and Mn concn., and residue. Aggressive action by corrosion, erosion, and sedimentation is summarized in chart form for various classes.—*CA*

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Suppose you had to put a filter plant in a high-cost residential area...

They did, in Montecito... and the neighbors all approve

The 1st of 2 advertisements on this installation

Montecito, California – near Santa Barbara – is all upper-bracket residential area. There is no industrial zoning, and the only commercial area is the town's block-square shopping center. But the Montecito Water District authorities, just last August, put in a million-gpd diatomite filter station right in the middle of a fine residential section – _with the full blessing of the entire neighborhood!_

Housed in a building which harmonizes with those in the area, the entire installation occupies only a single residential lot... in fact, before rezoning, it had been a residential lot.

Two filters, each with 600 ft² of filter area, filter 900,000 to 1,000,000 gallons of water per day into the District water system, yet the installation of filters, precoat tank and slurry feeder tank is housed in one room only 20′ x 40′. Labor averages less than 1½ man-hours per day. Total cost of this filter station, including land, structure, filter system and all piping, was held below $100,000.

Yes, they use Dicalite as the filteraid – Dicalite Speedex, to be exact, with a fibrous additive when precoating.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

DICALITE DEPARTMENT, Great Lakes Carbon Corp., 612 So. Flower St., Los Angeles 17, Calif.

(*Continued from page 72 P&R*)

Oxygen Corrosion Unnecessary in Plant Where Steam Is Main Product. J. M. TURNER & G. L. MANSFIELD. Elect. Light and Power, 35:88 ('57). Heavy corrosion of spray-type deaerator and assocd. equip. was effectively controlled by adding 0.05–10 ppm hydrazine to boiler makeup water taken from Delaware R. at Gibbstown, N.J. Residual N_2N_2 was detd. colorimetrically by using dimethylaminobenzaldehyde.—*CA*

Factors Other Than Mineral Content Influencing the Corrosiveness of Cooling Water. E. H. HURST. Corrosion, 13:696t ('57). Other factors in corrosiveness of cooling waters comprise microbiol. activity, silt and debris, suspended solids, dissimilar metals, and hydrocarbon poln. Bact. slime formed at 120°F. in water inoculated with slime from cooling tower showed definite increase in corrosion of mild steel under both summer and winter conditions, in presence of synergized polyphosphate or of chromate-phosphate inhibitor. With latter inhibitor, severe localized corrosion occurred with slime mixed with sulfate-reducing bacteria. No test data were obtained on Cu or alloys. Cooling-water system must be kept clean. —*CA*

Combating Corrision Phenomena in Hot-Water Supply Plants. F. RIEDEL. Wasserwirtsch.-Wassertech. (Ger.), 7:438 ('57). Theories for cause of corrosion are presented and discussed. Methods for resisting corrosion are described. Nature of phenomenon in hot-water supply systems is also considered. Present methods to control corrosion and new means to evaluate it are presented. Methods to aid in protection of inner walls of pipes are suggested. These include chem. treatment of water, sepn. of pipe wall entraining water by formation of protective layer, and constr. of equip. which has tapped areas for escape of O and CO_2. Electromagnetic action of water and its relation to corrosion and its liberation of solvent action is mentioned.—*CA*

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Decreasing the Aggressiveness of Soft Mountain Valley Water by Lime and Silicate Treatment. C. SIEGERT. Wasserwirtsch-Wassertech. (Ger.), **7**:227 ('57). 2 series of corrosion tests were made on cast iron and steel under action of following: (**I**) raw water; (**II**) water treated as in Dresden Coschutz water works; (**III**) water treated with lime, and (**IV**) water treated with Na silicate. In instance of **I**, **II**, and **III**, resp., pH was 6.6, 8.3, and 8.4 and hardness 10.7, 14.0, and 35.6 ppm $CaCO_3$. Loss in wt. after removal of rust was about same for all 3 but, thereafter, it was less for **III**, indicating formation of protective layer. Latter did not, however, extend below initially formed CO_2-derived rust nodules and O_2 attack continued under these. Greater corrosion observed for **II** than for **I** was attributed to promotion of O_2 attack by yellow Fe oxide-Fe local elements favored by higher pH of **II**. When pH of **III** was increased to 8.6–8.8, formation of rust nodules was avoided and, in this instance, as in **IV**, corrosion was eliminated over test period of 12 mo. This effect was lost in instance of **III** when hardness was reduced from 35.6 to 17.8. Protection against corrosion was due in instance of **III**, to layer having compn. CaO: Fe_2O_3 (18:82) and, in instance of **IV**, SiO_2:Fe_2O_3 (12:88).—*CA*

Corrosion of a City Water Distribution System. H. HOHN; G. JANGG; & H. BILDSTEIN. Gas, Wasser, Warme (Aust.), **11**: 76 ('57). Extensive corrosion of galvanized and cast-iron pipe, services, stopcocks, and brass and Zn valves was traced to overchlorination of water following World War II, and distr. of chlorinated well water before Cl had time to react. Numerous photomicrographs of corrosion product layers and photographs of damaged pipe and fittings are given. Anals. are given of Vienna water and of corrosion products. Storage of water for suitable period after chlorination greatly reduces corrosion but it is more practical to add phosphate to water as soon as it is pumped from wells, thus forming a protective coating that substantially eliminates corrosion. This treatment was entirely successful for Vienna system.—*CA*

Symposium on Corrosion. J. Inst. Heating, Ventilating Engrs. (Br.), **23**:453 ('56). **Corrosion of Heating and Ventilating Appliances.** D. G. LEWIS. In introduction to symposium on corrosion, held jointly by Institute of Heating and Ventilating Engrs. and Society of Water Treatment and Examn. in London in Nov. 1955, typical corrosion problems encountered in heating and ventilating systems were outlined and specific instances given as examples. **Corrosion of Ferrous Metals in Heat-Exchange Systems and Ancillary Equipment.** F. WORMWELL & G. BUTLER. Mechanisms involved in corrosion of ferrous metals under immersed and atmospheric conditions and of buried pipes and methods for corrosion prevention are outlined. **Corrosion of Nonferrous Metals in Heat-Exchange Systems and Ancillary Equipment.** H. S. CAMPBELL. Causes and means of prevention of corrosion of copper pipes in hot- and cold-water systems, of brass fittings, of galvanized steel, and mixed-metal systems are discussed.—*WPA*

POLLUTION CONTROL

The Role of the State Water Pollution Control Authority. D. B. LEE. Sewage and Ind. Wastes, **29**:196 ('57). Author discusses importance of state water poln. control authority in controlling poln. He considers that its function is to advise and recommend requirements for safe discharge of municipal and industrial wastes to surface and ground waters. In each case, most important factor is highest use for which receiving waters are required. Recourse should be taken to legal measures only as last resort.—*WPA*

Water Pollution. A. E. BERRY. Munic. Utilities Mag. (Can.), **93**:6:21 ('55). Author discusses, with particular reference to conditions in Canada, increasing problem of water poln. and describes methods of treating sewage and trade waste waters to reduce poln. Scope of various poln. control agencies is indicated.—*PHEA*

Necessary Measures in the Construction of Nuclear Reactors. O. JAAG. Mitt. Ver. Deut. Gewasserschutz, **8/9**:7 ('56). Author gives list of 14 requirements for protection of surface and ground waters from poln. by waste waters from nuclear reactors.—*WPA*

Organization and Accomplishments of the California Water Pollution Control Sys-

(*Continued on page 80 P&R*)

POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F

ONE SOURCE—ONE RESPONSIBILITY VITAL FACTOR IN EQUIPPING NEW INDUSTRIAL WATER TREATMENT PLANT!

Builders-Providence Controls and Equipment Installed at U. S. Steel's Fairless Works!

Cost-conscious industry realizes many distinct advantages in dealing with a single source. In water works plants, optimum operation depends upon the complete integration of many complex components. Builders-Providence, with the experience gained from thousands of performance-proven water works installations, provided U. S. Steel with such a source of controls and equipment.

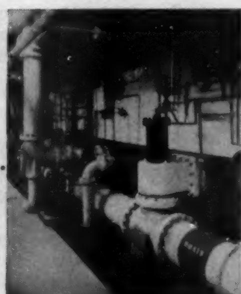
The comprehensive Builders line is designed for ease of integration . . . resulting in faster installation, lower operating costs, greater systems reliability, and minimum maintenance.

A single, responsible source for metering, control, valves, filter underdrains, wash water troughs, gas (liquid and dry) chemical feeders . . . backed by a nation-wide sales and service organization . . . saves time and money during the construction phase, the operating phase . . . and for years afterward!

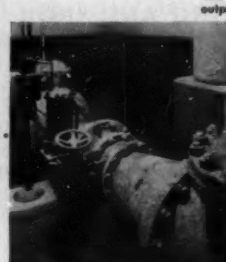
For complete satisfaction, insist on the high performance standards which Builders maintains through its nation-wide sales and service organization. Write **Builders-Providence, Inc., 335 Harris Avenue, Providence 1, R. I.**

Cost of water treatment chemicals, alum and hydrated lime, is minimized with Omega Universal Feeders, manufactured by a division of B-I-F Industries. The chemicals are applied in proportion to the flow of water, insuring correct dosage regardless of variations in plant output.

Builders Auto-Control Control Panel is equipped with manual and automatic controls . . . with audible alarms and lights to indicate any departure from desired conditions.



The special, angle-pattern, filter drain valve shown in foreground permits greater economy and simplicity of main piping. Building space is used efficiently. There is easy access for maintenance of equipment.



Flow of incoming water to be treated is metered and automatically held to a predetermined flow-rate through a Builders Automatic Venturi Flow Controller. The Builders rubber-lined Butterfly Valve is equipped for both automatic and manual emergency operation.

Builders automatic proportional Chlorinizer combined with Proportioneers Sodium Chlorite Feeder generates chlorine dioxide which is highly efficient in providing water free of taste, odors and harmful bacteria.

(*Continued from page 76 P&R*)

tem. A. M. Rawn & V. W. Bacon. Sewage and Ind. Wastes, **29**:201 ('57). Authors review recent developments in control of water poln. in state of California and plans for implementing provisions of Public Law 660 which extends and amends Federal Water Pollution Control Act.—*WPA*

A Cooperative Approach to a Stream-Pollution Problem. R. E. McKinney. J. Boston Soc. Civ. Engrs., **43**:61 ('56). In 1948, Research Dept. of Shawinigan Resins made studies of Chicopee R. poln. Composite samples of all their waste streams were taken. Portion of composite samples was neutralized to pH 8.5 with lime and aerated for 2 hr. 2nd portion was neutralized to pH 8.5 and aerated for 6 hr. Treated and untreated effluent samples were submitted for 5-day B.O.D. anals. In 1949, 50-gal drum of wastes from strongest waste stream was lime treated, and result was 50% B.O.D. reduction. Remaining B.O.D. was readily stabilized on trickling filters. Trickling filters were started on domestic sewage. pH was 3.1 and was adjusted to 6.7 with lime; 10% raw wastes were fed with sewage at rate of 13.3 mgd on 12-in. filter and 7.7 mil gal on 24-in. filter. It was found that wastes contained EtOAc, EtOH, AcOH, HCHO, butyraldehyde, NH_4OH, and H_2SO_4. Approx. 32% of 5-day B.O.D. of "B" still wastes could be removed by aeration and an overall efficiency of 89.6% removal was possible by combined aeration and filtration. —*CA*

SOFTENING AND IRON REMOVAL

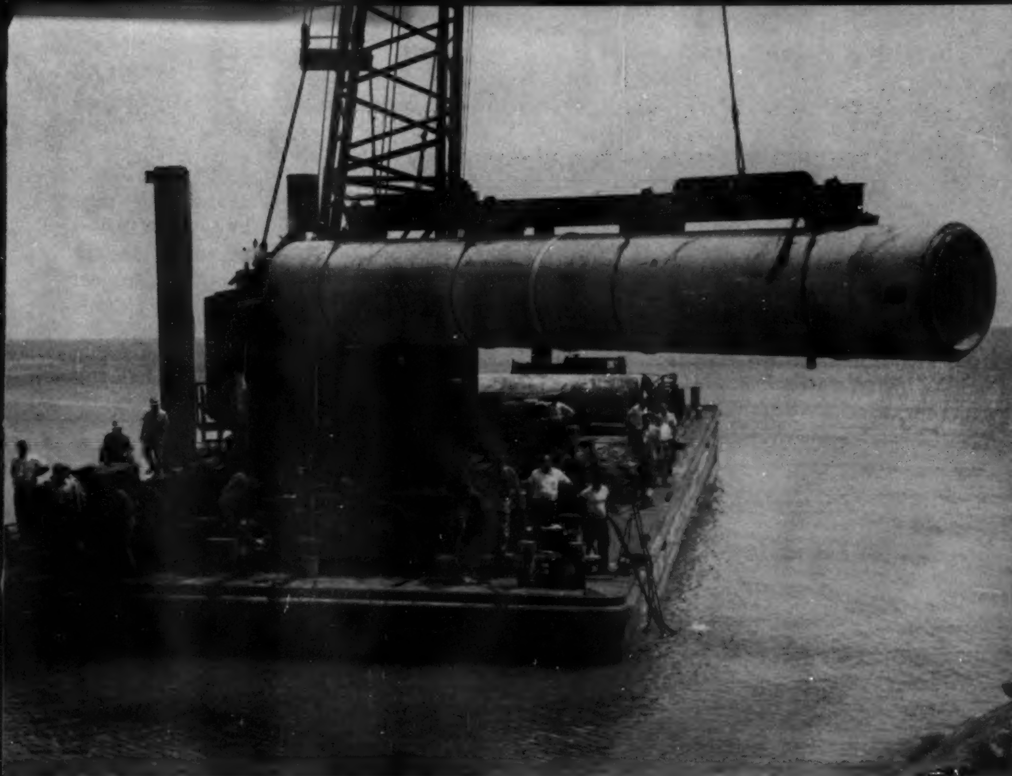
Equipment Necessary for Softening Water by Aid of Cation Exchangers. S. A. Abramov. Legkaya Prom. (USSR), **16**:5 ('56). Calcns. are presented for finding right dimensions of filter and of other parts, based upon Ca and Mg anals., of H_2O-softening equip. which uses as cation-exchange resin sulfocarbons SK-1, SM-1, SK-2, or SM-2.—*CA*

Weak-Base Anion-Exchange Resins for Domestic Water Conditioning. F. X. McGarvey & R. Kunin. Ind. Eng. Chem., **49**: 1907 ('57). 2 exchangers were used—Amberlite IR-45 and Amberlite XE-114. Regenerants used were ammonia and soda ash. Amt. of regenerant must be sufficient to neutralize CO_2 adsorbed by bed. This treatment produces slightly alk. H_2O, no increased hardness, and complete reduction of free acidity and free CO_2 with pH of 7.5–8.5. —*CA*

Combined Cation Treatment of Water With Sodium and Ammonium Ions. A. P. Mamet & S. M. Gurvich. Teploenergetika (USSR), **4**:47 ('57). Water is softened by aid of exchange resin which is regenerated, not with NaCl alone, but rather with mixt. of $NaCl + (NH_4)_2SO_4$ (**I**). This results in softened water which contains both $Na^+ + NH_4^+$. Such water is advantageous with respect to its application in turbines. Corrosion of blades is greatly reduced. Physicochem. data are presented. Abs. concns. of NaCl/I must be applied at various temps. to get right amts. of Na^+ and NH^+_4 into water. —*CA*

Regeneration of Cationites by Electrolysis. M. Zapan et al. Rev. Chim. (Bucharest), **8**:524 ('57). Efficient ion-exchange resins used for water softening are in general difficult to regenerate. Tests made with exhausted "Sulfocarbon" type resins showed that 1.5% H_2SO_4 soln. is more effective than 10% NaCl soln. By using simple electrolytic cell consisting of aluminum cathode and graphite anode and applying voltage of 8 v for H_2SO_4 and 8–12 v for NaCl soln. while it flows through cell contg. resin to be regenerated, exchange capac. of resin was increased by 15% as measured in meq. Ca^{2+}/g over previously used nonelectrolytic regeneration.—*CA*

Requirements in the Planning and Operation of Plants for Complete Removal of Salts. W. Wesly. Mitt. ver. Grosskesselbesitzer (Ger.), **38**:753 ('55). Plant for complete demineralization of water, with capac. of 225 cu m/hr is described. It is composed of 2 rapid reactors, 3 filter pumps, 3 Magno filters, 4 cation-exchange beds, and 4 anion-exchange beds. Procedure, anal. methods for control, and sources of error are described. Suggestions are made for reducing costs of chems. used for regeneration of ion-exchange materials and for reducing losses of water and exchange materials.—*WPA*



UNDERWATER WATER

Concrete Pressure Pipe Offers Many Advantages for Subaqueous Installations

Among these advantages is the ease with which the sections can be assembled. A simple gasket and two lug bolts between the sections provide a permanently watertight joint. There's no welding . . . no calking. This type of joint also provides flexibility.

Concrete Pressure Pipe is, of course, virtually maintenance free. It has strength, elasticity and cannot corrode. Its smooth interior surface stays that way. It will not tuberculate and initial carrying capacity is sustained.

For crossing rivers with water lines or sewer lines; for water intake lines; for outfall lines . . . you will find it advantageous to use permanent Concrete Pressure Pipe.

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 N. LaSalle Street
Chicago 1, Illinois

WATER FOR GENERATIONS TO COME

(*Continued from page 44 P&R*)

"Man, observing his world with a brain that is 90 per cent composed of water, hardly realizes his debt to that protean substance" was the opening statement of a 32-page discussion of "Water and the World Today" issued by the United Nations Dept. of Public Information in 1956. And just the other day, the UN indicated that it, at least, did realize the debt by assessing its repayments through the development of water resources during the next 40–50 years at several hundred billion dollars. Failure to take prompt action to provide for increasing domestic and industrial demands would be "not cautious, but reckless" was the conclusion of a UN panel of seven experts; they advocated a program through the UN for the preliminary phase of survey and planning which might take decades. The panel indicated that international cooperation must be nurtured, particularly because many of the world's larger streams cross national boundaries. Thus, the world, if not its people, seems to have recognized the importance of water supply. What prize, water, indeed!

Kenneth E. Shull, director of public relations for Philadelphia Suburban Water Co., Bryn Mawr, Pa., has been elected vice-president in charge of public relations and water quality control for the utility.

Baltimore, which has manufactured its own alum for the past 30 years at its Montebello Filtration Plant, has determined that it would be more economical to purchase the chemical. Accordingly, the Bureau of Water Supply has contracted with Olin Mathieson Chemical Corp. for 2,000 tons, enough for about a year.

WSIUD—the Water & Sewerage Industry & Utilities Div. of BDSA—has issued the following announcement to the water industry on the subject of water use data in the 1958 Census of Manufactures:

The problem of obtaining water use data as an integral part of the program for the 1958 Census of Manufactures and the 1958 Census of the Mineral Industries has been resolved. Although our Division preferred that the questionnaire cover the calendar year 1958, we recognize the difficulties involved in the operation of the Census and the desire of the Bureau of the Census to spread the workload into another year, thereby permitting more detailed analyses. This will be accomplished by having the questionnaire sent out later to cover the calendar year 1959. This will also permit ample time for review and analysis of the water use data from the 1954 Census and evaluation and revision of the water use questionnaire.

In order to assure essential periodic water use data collection, our recommendations are now as follows:

1. That the Bureau of the Census incorporate the water use survey as a part of its permanent program for the 5-year Censuses of Manufactures and Censuses of Mineral Industries, to be actually conducted in the year following each census.

2. That the intervening Annual Surveys of Manufactures be used for other surveys concerning water use as the need may be established, such as water use data on specified industries, specified regions and/or special phases of water utilization.

The above recommendations are under consideration by the Bureau of the Census, and we now believe are agreed to in essence subject to resolution of the details.

We now propose that we call together an informal work group of representatives from the federal government agencies interested in industrial water use to review the 1954 questionnaire and offer recom-

(*Continued on page 84 P&R*)

(*Continued from page 82 P&R*)

mendations for revision of the questionnaire for use in 1959. Following this, we propose to call in a nonfederal task group from industry to be composed of leaders in the water field, authorities on water use, and water resources development planners, to confer with our Division and the Bureau of the Census with reference to revision of the questionnaire in order to provide the data needed.

In addition to the above recommendations, in order to provide a bench mark year, we are also recommending the following:

1. That the Federal Power Commission survey the water use by the public utility steam generation of electric power plants for the year 1959.

2. That the Public Health Service collect and provide data on the water facilities and production of the major water supplies as of the end of the calendar year 1959, and similar data on the major public sewerage systems for the same year.

3. Other major categories of water use, such as rural domestic, irrigation, and federal government water use, should also provide data for the year 1959, but if this is not practicable, we may have to be satisfied with data for 1960.

Rice Institute is now offering graduate work in sanitary engineering, leading to an M.S. degree, under the auspices of the Dept. of Civil Engineering. Student participation in research activities is provided for, and graduate assistantships are available. For detailed information, write A. W. Busch, Asst. Prof., Dept. of Civil Engineering, Rice Institute, Houston 1, Tex.

(*Continued on page 86 P&R*)

(Continued from page 84 P&R)

Fallout has suddenly appeared as an argument against the fluoridation of New York City's water supply. Fallout, of course, has always been a considerable dental problem. Just how considerable was a surprise even to us when we discovered from a 1957 Public Health Service survey that no less than 21,000,000 people—i.e., an unlucky 13 per cent of the population—have lost all their teeth. But, actually, this is not the type of fallout that our New York antifluoridationists are concerned with. Rather it is the fallout of strontium 90, which a Passaic, N.J., dentist has suggested forms a compound with fluorides "that, in effect, reduces the rate at which strontium 90 is thrown off normally," leaving the body "exposed to that much more internal radiation." Pointing to this "warning that strontium 90 and fluorides make a dangerous combination," the New York *World-Telegram & Sun,* in an editorial, cites the dentist's advice to "go slow on fluoridation until this problem can be thoroughly researched."

Never an organization to pass up an opportunity, the Eastside Citizen's League Against Turnips wasted no time in issuing its own warning: "Strontium 90 and turnips," it pointed out, "make a dangerous combination." It was ECLAT's suggestion that we "go slow on turnips until we have 'unequivocal evidence' concerning:

"Reactions of strontium and turnips in living systems, particularly higher animals

"The effect of turnips on the excretion of strontium

"The effect of strontium on the excretion of turnips

"Interactions between strontium and turnips in water and in different soils."

We'll take peas!

(Continued on page 90 P&R)

(*Continued from page 86 P&R*)

Hugh F. Kennison, vice-president in charge of engineering and research, Lock Joint Pipe Co., East Orange, N.J., has been elected a director of the firm. He has been with Lock Joint since 1939.

John D. Bradley, president, Bunker Hill Co., San Francisco, has been elected president and chairman of the board of the Lead Industries Assn.

William C. Flanders has been named general manager of Gamon Meter Div., Worthington Corp. He was formerly assistant general manager, as well as general sales manager. His successor in the latter post is Andrew K. Richardson, Chicago regional sales manager.

Howard G. Egginson has been named New England district manager for Graver Water Conditioning Co., Div. of Union Tank Car Co., New York. His headquarters will be at 6 Beacon St., Boston.

Keith C. Stansmore has been named manager of the International Sales Area for Dorr-Oliver Inc., Stamford, Conn. He succeeds John H. E. Fedeler, who resigned.

Valvulitis is one of those distribution system diseases that is hard to hide and hard to find. At any rate, when an acute case struck Jersey City, N.J., last February, there was no hiding the fact, as a number of schools and factories had to be shut down for more than a day while the water department staff hunted for the proper valve to shut off a 1,300,000-gph leak. And at Westchester, Ill., 15,000 villagers were all too aware of having suffered water shortages for some 7 years until someone last April discovered that three of the system's valves had been left partially closed during that period, seriously reducing the flow. Open and shut cases if we've ever seen them.

General Waterworks Corp. has announced the purchase of one-third of the outstanding common stock of Cochrane Corp., manufacturers of treatment equipment and steel and alloy products.

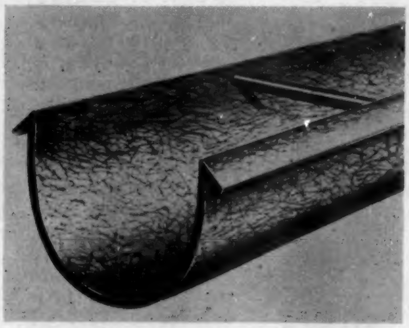
Robert D. Crane has been appointed assistant director of purchases for Dresser Industries, Inc., Dallas, Tex. He was formerly manager of purchases for Dresser Mfg. Div., Bradford, Pa.

(*Continued on page 92 P&R*)

(*Continued from page 90 P&R*)

John A. Andrea was erroneously reported in the March issue (p. 80 P&R) to have been named chief city engineer at Chapel Hill, N.C. The statement regarding his appointment is accurate, but the city involved is Durham, N.C., by which Mr. Andrea has been employed since 1947.

A plastic wash trough for filtration plants has been introduced by F. B. Leopold Co., Zelienople, Pa. Made of fiber glass–reinforced polyester-laminate plastic, the trough is said to be corrosion and weather resistant, durable, and easy and inexpensive to install.



Sand stops are an integral part of the trough, and the weir edges are mold formed, eliminating field grinding. The trough can be supplied in a number of cross-sectional dimensions, providing capacities to suit any requirement.

Gustav O. Hoglund, head of the Welding Section, Alcoa Process Development Lab., has been elected president of American Welding Society. The new AWS first vice-president is Charles I. MacGuffie, manager of marketing, Welding Dept., General Electric Co.

'Allied Chemical Corp.' is the new streamlined name for Allied Chemical & Dye Corp. The change is being made to reflect more clearly the broad nature of the firm's position in the chemical industry (its six operating divisions include Barrett, General Chemical, National Aniline, Nitrogen, Semet-Solvay, and Solvay Process). Although the dye business is still important to the company, there is no longer any reason to stress one particular line of products in the firm name.

Wine flows like water under the streets of Switzerland's Canton Valais, arriving in the bottling plant of the local wine merchant at a rate of 15 gpm. Source of the flow is the hillside cellars of the vineyardists, from where the pipes run at 3-ft depth some 3,600 ft into town. Savings in handling and transportation costs are expected to repay the capital outlay in 5 years—a little better than can be expected with water lines. According to reports, taste and quality of the wine are unimpaired—and there's a 90-ft head on it, too!

Roger W. Esty has been named sales manager for Natgun Corp., Boston, Mass. He was formerly with Public Works Supply Co., Lynn, Mass.

Sparling Meter Co., El Monte, Calif., has opened a Denver office, under the management of Howard Hatfield. The office is located at 1690 Milwaukee, Denver 6, Colo.

C. E. Schanze has retired after 20 years as manager of the Joplin (Mo.) Water Works Co. His successor is John O. Newton.

(*Continued on page 94 P&R*)

(*Continued from page 92 P&R*)

Edward Bartow, past president of AWWA, professor emeritus of the State University of Iowa, Iowa City, and an internationally recognized authority on water chemistry, died Apr. 12, 1958. He was 88. Born 1870 in Glenham, N.Y., he was graduated from Williams College in 1892 and received a doctorate from the University of Gottingen in 1895. He taught at Williams and at the universities of Kansas and Illinois before coming to Iowa, where he was head of the chemistry and chemical engineering departments from 1920 to 1940. He was the author of about 200 scientific articles, dealing largely with the chemistry of water and waste treatment.

An Honorary Member of AWWA (joined in 1906), he served as trustee (1914), vice-president (1921), and president (1922), and received the Fuller Award in 1951 on nomination by the Iowa Section. The many professional societies with which he was affiliated during his long and productive lifetime included ACS (president), AIChE (director), ASCE (life member), APHA, American Assn. for the Advancement of Science, American Society of Engineering Education, and Iowa Engineering Society. He was also a member of chemical societies in Great Britain and France and represented the United States at several international congresses.

Erwin M. Craig, superintendent of the Zion, Ill., water department, died Mar. 16, 1958, at the age of 55. A lifelong resident of Zion, he was born there in 1903 and attended Zion College. He became water superintendent at Zion in 1935, a position he held until his death. He was also superintendent of the Lake County (Ill.) Water Dist. An AWWA member since 1941, he was president of the West Shore Water Distributors Assn. and belonged to the Illinois Society of Professional Engineers.

William L. Havens, senior partner in the consulting firm of Havens & Emerson, Cleveland, Ohio, died Apr. 26, 1958, at the age of 64. Born in 1893 in Edmeston, N.Y., he received a degree in civil engineering from Cornell in 1916. In that year he took a position as engineer with Cleveland's Subdiv. of Sewage Disposal. In 1922 he left to become an associate in the consulting firm of George B. Gascoigne & Assocs., later Havens & Emerson. From 1940 until his death he was senior partner in general administrative charge of the Cleveland office of Havens & Emerson.

A Life Member of AWWA (joined in 1926), he also belonged to ASCE (president, Cleveland Section), NSPE, American Public Works Assn., Ohio Sewage & Industrial Wastes Treatment Conference, American Institute of Consulting Engineers, and Cleveland Engineering Society.

F. Victor Sohle, southwestern sales manager for R. D. Wood Co., Dallas, Tex., died Apr. 18, 1958, at the age of 63. Born in Mexico in 1894, he had been a resident of Dallas for the last 31 years, during most of which period he represented R. D. Wood Co. He had been in AWWA since 1942.

Service Lines

Venturi tubes are described and illustrated in a technical bulletin (No. 110-Pl), which discusses their design, installation, and use. The 32-page engineering bulletin may be obtained from Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I.

Flow colorimeters, which measure color intensity, turbidity, and chemical concentrations, are the subject of a brochure, No. 4000, issued by Beckman Instruments, Inc. The 4-page bulletin, describing the Beckman Model 77 Flow Colorimeter, may be obtained by writing the company's Process Instruments Div., 2500 Fullerton Rd., Fullerton, Calif.

Industrial gloves are described in detail in a new three-color catalog, which gives information to enable selection of the right type of liquidproof glove. The catalog is available by writing to the Pioneer Rubber Co., 296 Tiffin Rd., Willard, Ohio.

Vertical centrifugal pumps are described in a bulletin that includes specifications, sectional drawings, and performance ratings of this equipment. The 12-page bulletin (No. 726.2) is issued by Goulds Pumps, Inc., 40 Black Brook Rd., Seneca Falls, N.Y.

Swimming pool filtration equipment is described in a full-color, 24-page technical bulletin, No. 626. Color photographs, charts, and drawings are used to describe the types of filters available for public, commercial, and institutional pools. The bulletin may be obtained by writing the R. P. Adams Co., Inc., 473 E. Park Drive, Buffalo 17, N.Y.

(*Continued on page 98 P&R*)

Service Lines

(*Continued from page 96 P&R*)

Water treatment is outlined and illustrated in a 12-page booklet, "Outline of Modern Water Treatment Equipment." Numerous drawings aid in giving a "refresher course" in operation of various types of equipment. The booklet (Bulletin 4433) is available upon request from the Advertising Dept., The Permutit Co., 50 W. 44th St., New York 36, N.Y.

Concrete pressure pipe installation is described in detail in a revised edition of the manual "Concrete Pressure Pipe Laying Instructions." Photos, tables, and drawings are used in the 16-page, pocket-size booklet to illustrate the complete procedure. Copies may be obtained by writing to Price Brothers Co., 1932 E. Monument Ave., Dayton 1, Ohio.

Pump loads and stresses are discussed in an illustrated 8-page booklet, prepared from research into mechanical considerations in designing pumps. The booklet details the causes, effects, and cures of damaging radial loads. It may be obtained by requesting Engineering Bulletin No. EM-79 from the Peerless Pump Div., Food Machinery & Chemical Corp., 301 W. Avenue 26, Los Angeles 31, Calif.

Water heaters are described in a comprehensive report on indirect methods of heating water. The 8-page illustrated booklet (Bulletin IW-34), which outlines a procedure for estimating hot-water requirements, is available from Bell & Gossett Co., Morton Grove, Ill.

Demineralization, its principles, and types of equipment are the subject of a 30-page booklet recently made available. Illustrated with drawings and charts, this publication discusses applications of demineralizers, materials and design of ion exchange systems, and other details of operation. Copies may be obtained by writing for Bulletin WC-111A to Graver Water Conditioning Co., 216 W. 44th St., New York 11, N.Y.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Positions Available

ENGINEER
CHEMICAL or SANITARY

Young man to develop and expand the filter program of a 13 year old company, manufacturing water conditioning equipment for domestic, commercial, institutional, small municipal and industrial applications. National distribution. Present filter program involves swimming pools, laundry waste water, oil field water flooding and iron removal with diatomite and other type filters. Work directly under the Technical Director with wide latitude for independent judgment and action in laboratory studies, design, and field activity. Experience in water treatment and filtration necessary. Salary open. Replies confidential.

Bruner Corporation
4763 N. 32nd Street
Milwaukee, Wisconsin

PUBLIC HEALTH ENGINEER—Supervising public health engineer responsible for City food and general sanitation inspection, industrial hygiene, and typhus control programs. Requirements: Bachelor's degree in Civil, Sanitary, or Chemical Engineering. Applicants must be eligible to become registered professional engineer in State of Texas. Four years experience in public health or sanitary engineering. Salary range: $469–$623. Also position available for:

INDUSTRIAL WASTE ENGINEER—Advanced industrial chemical engineer with duties involving treatment and control of industrial waste disposal. Requirements: Degree in Chemical Engineering; four years experience in chemical engineering work involving treatment of industrial plant waste. Salary range: $469–$623.

Apply or write to: Civil Service Board, Room 401, Municipal Building, Dallas, Texas.

Positions Wanted

Professional Engineer with B.S. Degree in C.E., long water supply and swimming pool experience, interested in challenging position in water works field. Likes to meet public, 20 years with Health Department of large state, can write technical reports. Box 861, Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

Correspondence

Sic Semper Superintendent

To the Editor:

What a proud ancestral heritage present day water works superintendents can claim!

We doubt many could claim an ancestor arriving on the *Mayflower,* or having been with Captain John Smythe at Jamestown, or even participating in Christopher Columbus' or Leif Ericson's adventures in the New World. All, however, can proudly claim membership in the "Noble and Ancient Order of Afer."

Domitius Afer, a noted Roman orator and advocate, consul in 39 A.D. under Caligula, was superintendent of water supply circa 60 A.D. under Emperor Nero.

We wonder if Domitius Afer was the first of that honorable breed named "Superintendent of Water"?

Authority for Domitius Afer's title is the *Encyclopaedia Britannica.*

GEORGE ALAN BAER

York, Pa.
Mar. 17, 1958

We wondered for a moment whether this was a subtle attempt to undermine our current "Down With Superintendent" campaign (see October 1957 P&R, p. 39) but have convinced ourself that the writer merly intended to point out how old-fashioned that title really is.—ED.

Section Meetings

Illinois Section: The 1958 annual meeting of the Illinois Section was held at the LaSalle Hotel in Chicago Mar. 26–28. This was the largest meeting that the Section has ever had, as well as a most successful one educationally. The meeting was opened by Commissioner James W. Jardine, of the Chicago Water and Sewers Dept. Papers presented at the first afternoon session dealt with water resources, automatic lawn sprinkling, and relocation of utilities with special reference to highway construction. [A list of papers read at the meeting will appear in the December Journal.] The session was followed by a large committee meeting devoted to the preparation of a standard model ordinance for recreational use of reservoir land areas.

The business luncheon on Thursday was highlighted by an address on "Creative Thinking" by Dean R. G. Seymour, College of Commerce, University of Illinois. This was a most constructive feature of the program, and in the future more talks of this nature will be scheduled.

The afternoon program was devoted to the water supply problems of the area outside of metropolitan Chicago and various methods of financing. In the evening a cocktail party was provided by the manufacturers' representatives. They played host to 509 persons.

President Merryfield acted as master of ceremonies at the banquet, which was the largest ever held. Six Life Membership certificates were awarded. Jim Vaughn, head of the Safety Committee, presented 40 certificates for excellent safety operation of water plants throughout the state. This safety work is becoming an outstanding feature of the Section. Dewey Johnson, secretary-treasurer for many years, received the Fuller Award nomination.

The trustees, at their annual meeting, passed a resolution to make the 50th anniversary meeting in 1959 the largest and most outstanding ever to be held by the Illinois Section. Committees were appointed and preliminary plans started. (There is still one man in the Section who helped found the original parent organization 50 years ago, Lewis I. Birdsall.)

The social activities and entertainment, under the direction of J. H. Whisler, were greatly enjoyed.

Dewey W. Johnson
Secretary-Treasurer

New York Section: A total of 339 members and guests turned out for the New York Section's Spring Meeting Mar. 26–28, 1958, at the Van Curler Hotel in Schenectady. Papers presented covered such subjects as civil defense, pipe joints, the manager's job, underground installations at Schenectady, and centrifugal pumps. [A complete list will appear in the December Journal.]

Following the annual banquet, Lewis Smith, manager of the Rochester water works, received the Fuller Award nomination for his outstanding work and devotion to the industry. President Finch (then president-elect) presented Life Membership certificates to William F. End, Ross Valve Co., Troy; R. K. Johnson, Darling Valve & Mfg. Co., New

(*Continued on page 104 P&R*)

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Section Meetings

(Continued from page 102 P&R)

York; James R. Losee, Water & Sewer Dept., Tarrytown; Philip L. McLaughlin, Bay Shore; and Frederick H. Weed, Hartsdale.

Friday morning, following a hearty breakfast, the Round Table Conference was held. The topics under discussion were telemetering for small water systems, main breaks, fire hydrants in winter, pipe joints, standpipe and steel reservoir maintenance, and distribution system flushing.

An invitation to visit the city pumping station was extended by John Meehan, water works engineer, Schenectady, to all who were interested. A get-together party, sponsored by WSWMA, was held on Wednesday evening. A gala cocktail hour, also sponsored by WSWMA, preceded the banquet on Thursday. Music provided by an accordion inspired Section members to form a quartet which entertained the group with a few songs.

KIMBALL BLANCHARD
Secretary-Treasurer

Southeastern Section: More than 400 members and guests assembled at the Dinkler Plaza Hotel, Atlanta, Ga., on Mar. 23–26, when the Southeastern Section held its 29th annual meeting. Official registration totaled 446, including 143 ladies, which was by far the largest attendance at any of the Section's meetings.

Beginning on Monday morning 2 full days of technical sessions were held at the hotel, with an inspection trip to the Atlanta water works on Wednesday. Various operational phases of the water works field were dealt with by a group of informed speakers. The sessions were well

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Section Meetings

(*Continued from page 104 P&R*)

attended throughout, with several of the papers stimulating lively discussions. [A complete listing of the technical program will be carried in the December issue of the JOURNAL.]

Despite unfavorable weather conditions, approximately 300 persons spent Wednesday morning at the Atlanta Water Dept. Service Building viewing a series of demonstrations arranged by General Manager Paul Weir and his staff, in cooperation with W. D. Hudson, Pitometer Assocs., Milton Aycock, Centriline Corp., and others. These demonstrations included the use of Mueller Co. equipment for inserting valves in water mains under pressure; a study of the actual loss of head under changing rates of flow through each unit of an extensive network of varying sizes of pipe containing numerous valves, meters, fittings, and other appurtenances; cleaning of cast-iron pipe; the latest methods used by Centriline Corp. for applying cement lining; mechanical cutting of large-diameter pipe; use of electronic pipe and valve locators; and use of other mechanical equipment.

Social functions included a buffet dinner Sunday evening, given by Paul Weir and some of his friends and associates, which was thoroughly enjoyed by almost 400 guests. The Section's annual banquet and dance on Tuesday evening was equally well attended.

At the banquet, announcement was made that Lewis R. Simonton, superintendent of water treatment, Griffin, Ga., was the Section's choice to receive the Fuller Award. George W. White, consulting engineer, Spartanburg, S.C., was presented with a Life Membership certificate. Twenty-five-year Membership pins were presented to Louva G. Lenert, director of sanitary engineering, Georgia Dept. of Public Health, Atlanta; L. E. Wallis, superintendent, Water Dept., Blakeley, Ga.; and M. B. Cooper, retired superintendent of water works, Augusta, Ga. The Safety Committee announced that Safety Awards of Merit were being presented to the water plants of Celanese Corp., Rome, Ga.; Thomaston Mills, Thomaston, Ga.; and Duke Power Co., Anderson, S.C.

The Section's business meeting was held at noon Tuesday, when officers for the ensuing year were elected. John R. Bettis, Charleston, S.C., was elected chairman; Lewis R. Simonton, Griffin, Ga., vice-chairman; M. E. Henley, Atlanta, trustee; and Carl C. Lanford, Greer, S.C., director.

The visiting ladies were entertained at a series of events arranged by Mrs. J. M. Roberts, chairman, and Mrs. M. E. Henley, cochairman, of the Ladies' Entertainment Committee and their efficient subcommittees. These events included a bus trip on Monday to Atlanta's famous Civil War Painting at the Cyclorama and from there to the Cherokee Country Club for lunch; a Coffee and Fashion Show on Tuesday morning; and a tea Tuesday afternoon. All of these events were well attended.

As has been the custom at Southeastern Section meetings in recent years, Club Room entertainment was provided by the manufacturers' representatives. This year these functions were conducted in a most excellent manner under the able direction of Charles F. Lynn, Lock Joint Pipe Co., Columbia, S.C.

Cocktail hours Sunday, Monday, and Tuesday evenings, a "Meet and Greet" party Sunday night, and Club Room facilities available following the banquet Tuesday night contributed greatly to the social festivities.

The meeting ended after a buffet luncheon at the Atlanta water works Wednesday noon with the group again being the guests of Paul Weir and his friends and associates.

N. M. DEJARNETTE
Secretary-Treasurer


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AMERICAN WATER WORKS ASSOCIATION

NEW MEMBERS

Applications received Apr. 1–30, 1958

Allen, Quinton *see* Bastrop (Tex.) Utilities Dept.

Ausman, E. Murray, Gen. Mgr., George Kent, Ltd., 389 Horner Ave., Toronto 14, Ont. (Apr. '58) *M*

Bailey Meter Co., R. W. Duesnsing, Mgr., 1050 Ivanhoe Rd., Cleveland 10, Ohio (Assoc. M. Apr. '58)

Banks, V. James, M. E. Beth-Cornwall Corp., Cornwall, Pa. (Apr. '58) *MRPD*

Barrett, Clarence M., Jr., Chemist & Bacteriologist, Chloromerger Co., Inc., Athens, N.Y. (Apr. '58) *P*

Bastrop Utilities Dept., Quinton Allen, Supt., 902 Main St., Bastrop, Tex. (Corp. M. Apr. '58) *MRPD*

Batz, Michael E., Water Chemist, The Chemstreand Corp., Pensacola, Fla. (Apr. '58) *MP*

Benedict, Earl N., Service Engr., Infilco, Inc., Tucson, Ariz. (Apr. '58) *P*

Bennett, Edwin R., Graduate Student, Washington Univ., St. Louis 5, Mo. (Jr. M. Apr. '58) *P*

Berry, Arthur, Supt. of Const., Water Works, City Hall, Jackson, Miss. (Apr. '58) *MD*

Bishop, V. A., Steel Dept. Mgr., Evans, Coleman & Evans, Ltd., Ft. of Columbia St., Vancouver, B.C. (Apr. '58)

Broadmoor Water Corp., Phillip M. Weinstein, Pres., 6930 N.W. 27th Ave., Miami 47, Fla. (Corp. M. Apr. '58)

Broeker, Dale M., Supt. of Water, City Hall, West Burlington, Iowa (Apr. '58) *D*

Byrne, Francis Oliver, Director, Engineering Supplies, Ltd., St. Helier Chambers, 27 Hill St., St. Helier, Jersey, Channel Island, England (Jan. '58) *RPD*

Callaway, James Lamar, Water Works Foreman, Water Works, 651—14th St., N.W., Atlanta, Ga. (Apr. '58) *D*

Campbell, Laurie Lake, City Comr., Box 17, City Hall, Jackson, Miss. (Apr. '58) *MRPD*

Carson, John W., Water Supt., Lovilia, Iowa (Apr. '58) *MRPD*

Charles, Robert Simpson, III, Sales Engr., Layne-New York Co., Inc., 5655 Bryant St., Pittsburgh 6, Pa. (Apr. '58) *RP*

Cleutat, F. N., Water Bd. Comr., St. Bernard Water Dist. 1, Chalmette, La. (Apr. '58) *MP*

Clark, Harold F., Bacteriologist, Robert A. Taft San. Eng. Center, 4676 Columbia Parkway, Cincinnati 26, Ohio (Apr. '58) *P*

Clifton, Troy Thomas, Asst. Mgr., Water Dept., Corinth, Miss. (Apr. '58) *PD*

Coger, Paul C., Mgr., W. Va. Water Service Co., Box 1069, Welch, W. Va. (Apr. '58) *M*

Collins, Howard J., Supt., Utilities, City Hall, Moultrie, Ga. (Apr. '58) *M*

Conn, Ronald L., Sales Engr., Apparatus Sales Div., General Electric Co., 1312 Live Oak St., Houston 1, Tex. (Apr. '58) *MR*

Cowan, Horace G., Supt., Light & Water & Sewer, Com. of Public Works, Westminster, B.C. (Apr. '58)

Crawford, Ralph P., Water Supt., Rotterdam Water Dist. 3, Rotterdam Junction, N.Y. (Apr. '58)

Crowley, Thomas F., San. Engr., Water Safety Control Sec., Water Dept., 3300 E. Cheltenham Pl., Chicago, Ill. (Apr. '58) *PD*

Custer, David J., Engr., 2120 Maryland Ave., Baltimore 18, Md. (Apr. '58) *D*

Custer, Richard Holmes, City Mgr., City Hall, Zanesville, Ohio (Apr. '58)

Dantzler, John E., Student, A&M College of Texas, Box 5284, College Station, Tex. (Jr. M. Apr. '58)

Davis, Charles C., Jr., Maint. Supervisor, Lockheed Aircraft Corp., Georgia Nuclear Labs., Dawsonville, Ga. (Apr. '58) *MPD*

DeKlotz, Fred W., Div. Sales Mgr., Pittsburgh-Des Moines Steel Co., Santa Clara, Calif. (Apr. '58)

Diaz, Louis P., Water Bd. Comr., St. Bernard Water Bd. Dist. 1, Chalmette, La. (Apr. '58) *MP*

DuByrne, Frank Thomas, Supt., Services & Utilities, Campbell Soup Co., Napoleon, Ohio (Apr. '58) *MPD*

Duesnsing, R. W.; *see* Bailey Meter Co.

Dufour, Lee J., Vice-Pres., St. Bernard Water Bd. Dist. 1, Chalmette, La. (Apr. '58) *MPD*

Dunn, Billie M., (Mrs.), Office Mgr., Water Works, Jackson, Miss. (Apr. '58) *M*

Dyer, Bird L., Supt., Mayfair Water Co., 108 E. San Anselmo Ave., Stockton, Calif. (Apr. '58) *MD*

Dyer, Jack, Supt., Water Works, Box 901, Marfa, Tex. (Apr. '58)

Emery, Paul M., Chief Works Engr., Water Works, 20 Eglington Ave., E., Toronto, Ont. (Apr. '58)

Enzweiler, R.; *see* Village of Park Forest (Ill.) Water Dept.

Escalch, Pierre, Water Bd. Comr., St. Bernard Water Bd. Dist. 1, Chalmette, La. (Apr. '58) *MPD*

Finnell, Walter James, Asst. Supt., Water Div., Dept. of Public Utilities, Box 1639, Tacoma 1, Wash. (Apr. '58) *M*

Fitch, Howard L., Sales Engr., Western Water Works Supply Co., Box 102, El Monte, Calif. (Apr. '58) *D*

Forehand, Luther W., Water Supt., 204 N. Vanderveer St., Burnet, Tex. (Apr. '58) *MRPD*

Fox, Barbara Gene, (Miss), San. Engr., City of Chicago, 3300 E. Cheltenham, Chicago, Ill. (Jr. M. Apr. '58) *PD*

French, Harold L., Performance Test Supervisor, Revco, Inc., Deerfield, Mich. (Apr. '58) *MPD*

Fridy, Thomas A., Jr., Civ. Engr., Lockwood Greene Engrs., Inc., Spartanburg, S.C. (Apr. '58)

Froebel, Carl A., Owner, Carl A. Froebel & Co., 1246 Hampton, St. Louis 10, Mo. (Apr. '58) *MPD*

Fry, Nevin, Acting Mgr., Southwestern Pa. Water Authority, Box 1029, Clarksville, Pa. (Apr. '58)

Gagen, Thomas, Gen. Supt., Public Utilities Com., London, Ont. (Apr. '58) *MRPD*

Gottshall, Wayne Z., Chief Chemist, Napoleon Plant, Campbell Soup Co., Napoleon, Ohio (Apr. '58) *RP*

Gove, John R., Cons. Engr., 310 S. Main St., Hendersonville, N.C. (Apr. '58) *RPD*

Griggs, C. J.; *see* City of Mesquite (Tex.)

Grizzell, Leon R., Supt., Olympic View Water Dist., 23725 Edmonds Way, Edmonds, Wash. (Apr. '58)

Gros, Irvin J., Supt., Water Plant, St. Charles Water Works Dist. 2, Luling, La. (Apr. '58) *P*

Haddaway, Vaden J., Project Engr., Whitman, Requardt & Assoc., 1304 St. Paul St., Baltimore 2, Md. (Apr. '58) *MRPD*

Hagerstrom, M. G., Civ. Engr., Casler & Stapleton, 202 S. Church St., Jacksonville, Ill. (Apr. '58) *RP*

Handley, Dodd E., Supt., Water Works, Monticello, Ark. (Apr. '58) *RPD*

Harmeson, Donald K., Director, Div. of San. Eng., State Bd. of Health, 510 Pennsylvania Ave., Dover, Del. (Apr. '58)

Harris, J. B., Water Supt., City Hall, Italy, Tex. (Apr. '58) *MPD*

Hatch, Chester, Jr., Cons. Chem. Engr., 426 N. Pleasantburg Dr., Greenville, S.C. (Apr. '58) *P*

Heath, Donald M., Indus. Staff Specialist, Morton Salt Co., 107 S. 8th Ave., La Grange, Ill. (Apr. '58)

(*Continued on page 112 P&R*)

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(*Continued from page 108 P&R*)

Hiser, Lee L., Field Sales Engr., Infilco, Inc., Houston, Tex. (Apr. '58) *RP*

Houston, N. A., Sales Repr., Pump Dept., Railway & Power Eng. Corp., Ltd., 197 Eastern Ave., Toronto, Ont. (Apr. '58)

Huston, D. A., Partner, Civ. Eng., Hege & Huston, 10154 S.W. Park Way, Portland 25, Ore. (Apr. '58) *PD*

Hustvedt, Anders Otis, Village Engr., Box 986, Flushing, Mich. (Apr. '58) *M*

Hutchinson, Thomas P., Dist. Engr., Infilco, Ltd., 5925 Monkland, Montreal, Que. (Apr. '58) *P*

Jackson, Leon W., Partner, John A. Carollo, 3308 N. 3rd St., Phoenix, Ariz. (Apr. '58) *PD*

Johnson County Water Dist. 1, L. S. McArthur, Gen. Mgr., 5916 Dearborn, Mission, Kan. (Corp. M. Apr. '58)

Jordan, William Russell, Jr., Cons. Civ. Engr., 3696 Teal Rd., Chamblee, Ga. (Apr. '58) *PD*

Kallin, Francis, Chief Civ. Engr., Ford Motor Co., The American Rd., Dearborn, Mich. (Apr. '58) *MRPD*

Kiernan, Thomas Michael, Jr., Sales Engr., Electro Rust-Proofing Corp., 20 Main St., Belleville, N.J. (Apr. '58)

King, G. H., Supt., Munic. Water Dept., 209 N. Myrtle St., Warren, Ark. (Apr. '58) *PD*

King, Robert H., Supt., Water Dept., 4305 Santa Fe Ave., Vernon 58, Calif. (Apr. '58) *MRPD*

Kukuk, Donald H., Engr., Boyle Eng., 3913 Ohio St., San Diego 4, Calif. (Apr. '58) *RPD*

Lynch, Eugene F., Utilities Engr., Gulf Oil Corp., Box 1166, Pittsburgh 30, Pa. (Apr. '58) *P*

McArthur, L. S.; *see* Johnson County (Kans.) Water Dist. 1

McCallum, James J., Asst. Water Comr., Glen Ellyn Water Dept., 498 Pennsylvania Ave., S.E., Wheaton, Ill. (Apr. '58) *M*

McKenna, Pat H., Owner, Triple XXX Bottling, 1728 Ave. A, Galveston, Tex. (Apr. '58) *P*

Meredith, Robert Arthur, Civ. Engr., Lutz & May Co., 819 Finance Bldg., Kansas City 5, Mo. (Apr. '58) *RPD*

Mesquite, City of, C. J. Griggs, City Mgr., City Hall, Mesquite, Tex. (Munic. Sv. Sub. Apr. '58) *MD*

Mills, Ralph E., Jr., Engr., Wiedeman & Singleton, Box 1878, Atlanta 1, Ga. (Apr. '58) *MRPD*

Morgenthaler, Ralph Lewis, Vice-Pres., Western Plastics Corp., 3110 Ruston Way, Tacoma 2, Wash. (Apr. '58) *D*

Navin, Frank E., Supt., Bd. of Public Works, 33 Gordon St., South River, N.J. (Apr. '58) *MRPD*

Naylor, William Perry, Asst. Civ. Engr., Long Beach Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '58) *MRP*

Nevin, Robert L., Engr., Leeds, Hill & Jewett, 609 S. Grand, Los Angeles 17, Calif. (Apr. '58) *RD*

Newton, Roger J., Sales Repr., Southern Eastern States, Chem. Fire & Rust Proofing Corp., 50 Cutter Mill Rd., Great Neck, N.Y. (Apr. '58) *RP*

Noell, Barbara J., (Miss), Water Chemist, South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Jr. M. Apr. '58) *RP*

Nunez, Albert, Water Purification Plant Operator, St. Bernard Water Bd. Dist. 1, Chalmette, La. (Apr. '58) *PD*

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Nunez, Joseph E., Asst. Supt., Water Purification Plant, St. Bernard Water Dist. 1, Chalmette, La. (Apr. '58) *P*

O'Loughlin, Charles A., Sales Repr., A. Y. McDonald Co., 12th & Pine St., Dubuque, Iowa (Apr. '58) *MD*

O'Rourke, Frank L., Supt., Water Works, DeValls Bluff, Ark. (Apr. '58) *M*

Osborn, Richard D., Water Controlman, American Sugar Ref. Co., 7417 N. Peters St., Arabi, La. (Apr. '58) *MP*

Park Forest, Village of, Water Dept., R. Enzweiler, Supt., Village Hall, Park Forest, Ill. (Corp. M. Apr. '58)

Parker, George W., Jr., Salesman, Johns-Manville Corp., Box 1685, North Miami, Fla. (Apr. '58) *D*

Passe, Harold F., Foreman, Water Dept., Red Wing, Minn. (Apr. '58) *D*

Paz, Antonio J., Supt., Public Water Works, Cartagena, Colombia (Jan. '58) *MRPD*

Pettis, Charles E., Partner, Finkbeiner, Pettis & Strout, 2130 Madison Ave., Toledo 2, Ohio (Apr. '58) *P*

Pienvichitr, Vithya, Graduate Student, Univ. of Illinois, Urbana, Ill. (Jr. M. Apr. '58) *MRP*

Piotrowski, Karol R., Civ. Engr., American Civil Engineers, G-4121 Beecher Rd., Flint 4, Mich. (Apr. '58) *MRPD*

Polenske, Richard E., Vice-Pres., in charge of Operations, Arizona Water Co., Box 5347, Phoenix, Ariz. (Apr. '58) *MD*

Puckett, Charles E., Storekeeper, Water Dept., 3854 Mulberry St., Riverside, Calif. (Apr. '58) *D*

Ramona Munic. Water Dist., James W. Smith, Chairman of the Bd., 703 Main St., Ramona, Calif. (Munic. Sv. Sub. Apr. '58) *MRPD*

Reed, Robert L., Tech. Director, Betz Labs., Ltd., 384 St. Paul St., W., Montreal, Que. (Apr. '58) *RP*

Rollins, Charles A., Sr. Engr., John A. Carollo, 3308 N. 3rd St., Phoenix, Ariz. (Apr. '58) *MD*

Ruesch, L. J., San. Engr., Chain Belt Co., Milwaukee, Wis. (Apr. '58) *P*

Rummelsburg, Arnold S., Asst. Engr., Ventura River Munic. Water Dist., 480 N. Ventura, Ventura, Calif. (Apr. '58) *MRD*

Russ, Emmanuel Edmond Alexandre, Tech. Agent, Water & Electricity Co. of Indo China, 72 Duong Hai Ba Trung, Saigon, Viet-Nam (Jan. '58) *RPD*

Schwarz, Lester Louis, Water Plant Supt., Water Dept., Florence Ave., Point Pleasant, N.J. (Apr. '58) *MRPD*

Scott, Joel Aaron, Operator, Water Treating Plant, Union Carbide Corp., Institute, W. Va. (Apr. '58) *P*

Shigley, Lucius E., Supt., Winston-Dillard Water Dist., Box 125, Winston, Ore. (Apr. '58) *MRPD*

Shobe, Richard Ab., Meter Supervisor, Water Div., E. 914 Grace, Spokane, Wash. (Apr. '58) *M*

Sibley, William Harold, Burford, Hall & Smith, Box 1339, Atlanta 1, Ga. (Apr. '58) *P*

Simmons, Thomas Maurice, Water & Sewage Supt., 215 S. 5th St., Junction, Tex. (Apr. '58) *MPD*

Smith, E. F., Jr., Supervisor of Accounting & Collections, Water Works, 2015 Commerce St., Dallas, Tex. (Apr. '58) *M*

Smith, James B., Engr., Howard L'Heureux & Assocs., 803 Murray St., Alexandria, La. (Apr. '58) *PD*

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Smith, James W.; *see* Ramona (Calif.) Munic. Water Dist.

Smythe, J. J., The Amherst Water Co., 205 Lorain County Savings & Trust Bldg., Amherst, Ohio (Apr. '58) *MD*

Sonido, Pablo P., Chief, Eng. Div., Water & Sewage Sec., U.S. Army Eng. Dist. APO 331, Okinawa, Ryukyu Islands (Apr. '58) *MRP*

Sorci, Phillip, Water Purification Plant Operator, St. Bernard Water Bd. Dist. 1, Chalmette, La. (Apr. '58) *MP*

Stiles, James Fuller, III, Stiles Karlsonite Corp., 1550 Grand Ave., Waukegan, Ill. (Apr. '58) *P*

Stoltz, Reynold W., Supt., Munic. Utilities, Box 55, Blooming Prairie, Minn. (Apr. '58) *MPD*

Stone, Ormond Allison, Design Engr., Forrest & Cotton, 600 Vaughn Bldg., Dallas 1, Tex. (Apr. '58) *P*

Stowell, Edwin R., Dewante & Stowell, 2015 J St., Sacramento, Calif. (Apr. '58) *R*

Stramel, Gilbert J., Hydrologist, Water Dept., City Hall Annex, Wichita, Kan. (Apr. '56) *MR*

Sudweeks, Calvin Keith, San. Engr., State Dept. of Health, 122 Capitol Bldg., Salt Lake City, Utah (Apr. '58) *RP*

Swanson, Frank Emanuel, Asst. Civ. Engr., Long Beach Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '58) *M*

Swor, Leland D., Supt., W. Va. Water Service Co., Montgomery, W. Va. (Apr. '58) *MPD*

Terhune, James, Sales Repr., Ludlow Valve Mfg. Co., Inc., 11 W. 42nd St., New York, N.Y. (Apr. '58)

Tinkey, Arnold Michael, San. Engr., Univ. of Ill., Hamburg, Ill. (Jr. M. Apr. '58) *PD*

Tremblay, Solyme, Cons. Engr., 18 Murray Gardens, Pointe Claire, Que. (Apr. '58)

Von Raesfeld, Donald Ralph, Water Supt., 500 Benton St., Santa Clara, Calif. (Apr. '58) *D*

Walling, Clevie L., Supt., Water & Sewer Dept., Valhalla, S.C. (Apr. '58) *M*

Walters, Druery Graham, Supt., Water Works, Dillon, S.C. (Apr. '58) *MD*

Weill, Stancil Brent, Sales Engr., Wallace & Tiernan, Inc., 3 Rhodes Center, N.W., Atlanta, Ga. (Apr. '58) *P*

Weinstein, Phillip M.; *see* Broadmoor Water Corp.

Westad, Rolf, Sales Engr., Johns-Manville Sales Corp., 22 E. 40th St., New York 16, N.Y. (Apr. '58) *RD*

Williams, George Elliott, Asst., Civ. Engr., Long Beach Water Dept., 215 W. Broadway, Long Beach 2, Calif. (Apr. '58) *M*

Willis, George D., Water Supt., 330 S. 3rd St., Slaton, Tex. (Apr. '58) *MPD*

Wolfe, Miles M., Supt., Water Works, Cumming, Ga. (Apr. '58) *MP*

Woods, Paul A., Mgr., Solvent Mfg. Co., Rte. 3, Box 353G, Oklahoma City 7, Okla. (Apr. '58) *PD*

Wootten, Tom Robinson, Merritt & Welker, Marietta, Ga. (Apr. '58)

Worthington, Richard T., Engr., Cornell Howland Hayes & Merryfield, 1600 Western Ave., Corvallis, Ore. (Apr. '58) *PD*

Wright, John W., Partner, Kappele, Wright & MacLeod, Ltd., 531 Yonge St., Toronto 5, Ont. (Apr. '58)

Yates, Joseph O., Jr., Mgr., The Ohio Cities Water Co., American Water Works Service Co., 102 E. Perry St., Tiffin 16, Ohio (Apr. '58) *M*

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Industrial Chemical Sales Div.
Permutit Co.

Activated Silica Generators:
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

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General Chemical Div.
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Ross Valve Mfg. Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Chemists and Engineers:
(See Professional Services)

Chlorination Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Precision Chemical Pump Corp.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Chlorine Comparators:
Klett Mfg. Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Chlorine, Liquid:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Clamps and Sleeves, Pipe:
James B. Clow & Sons
Dresser Mfg. Div.
M. Greenberg's Sons
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.

Clamps, Bell Joint:
James B. Clow & Sons
Dresser Mfg. Div.

Clamps, Pipe Repair:
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.

Clarifiers:
American Well Works
Chain Belt Co.
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.
Walker Process Equipment, Inc.

Coagulant Aids:
Hagan Chemicals & Controls, Inc.

Condensers:
Alco Products, Inc.
Allis-Chalmers Mfg. Co.
United States Pipe & Foundry Co.

Contractors, Water Supply:
Layne & Bowler, Inc.

Controllers, Liquid Level, Rate of Flow:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Foxboro Co.
General Filter Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Copper Sheets:
American Brass Co.

Copper Sulfate:
General Chemical Div.
Tennessee Corp.

Corrosion Control:
Alco Products, Inc.
Calgon Co.
Industrial Chemicals, Inc.
Philadelphia Quartz Co.

Couplings, Flexible:
DeLaval Steam Turbine Co.
Dresser Mfg. Div.

Desalinization Plants:
Maxim Silencer Co.

Diaphragms, Pump:
Dorr-Oliver Inc.

Engines, Hydraulic:
Ross Valve Mfg. Co.

Engineers and Chemists:
(See Professional Services)

Evaporating Equipment:
Maxim Silencer Co.

Feedwater Treatment:
Allis-Chalmers Mfg. Co.
Calgon Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Industrial Chemicals, Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)

Ferric Sulfate:
Tennessee Corp.

Filter Materials:
Anthracite Equipment Corp.
Carborundum Co.
Dicalite Div.
General Filter Co.
Johns-Manville Corp.
Northern Gravel Co.
Permutit Co.
Stuart Corp.

Filters, incl. Feedwater:
Dorr-Oliver Inc.
Graver Water Conditioning Co.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Roberts Filter Mfg. Co.
Ross Valve Mfg. Co.

Filtration Plant Equipment:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chain Belt Co.
Cochrane Corp.
Filtration Equipment Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
F. B. Leopold Co.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Roberts Filter Mfg. Co.
Simplex Valve & Meter Co.
Stuart Corp.
Wallace & Tiernan Inc.

Fittings, Copper Pipe:
Dresser Mfg. Div.
M. Greenberg's Sons
Hays Mfg. Co.
Mueller Co.

Fittings, Tees, Ells, etc.:
Alco Products, Inc.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
M & H Valve & Fittings Co.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Flocculating Equipment:
Chain Belt Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
F. B. Leopold Co.
Permutit Co.
Stuart Corp.

Fluoride Chemicals:
American Agricultural Chemical Co.
Tennessee Corp.

Fluoride Feeders:
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Co., Inc.

Furnaces:
Jos. G. Pollard Co., Inc.

Gages, Liquid Level:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Gages, Loss of Head, Pressure of Vacuum, Rate of Flow, Sand Expansion:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foxboro Co.
Jos. G. Pollard Co., Inc.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Gasholders:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Gaskets, Rubber Packing:
James B. Clow & Sons
Johns-Manville Corp.

Gates, Shear and Sluice:
Armco Drainage & Metal Products, Inc.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Mueller Co.
R. D. Wood Co.

Gears, Speed Reducing:
DeLaval Steam Turbine Co.

Glass Standards—Colorimetric Analysis Equipment:
Klett Mfg. Co.
Wallace & Tiernan Inc.

Goosenecks (with or without Corporation Stops):
James B. Clow & Sons
Hays Mfg. Co.
Mueller Co.

Hydrants:
James B. Clow & Sons
Darling Valve & Mfg. Co.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Rensselaer Valve Co.
R. D. Wood Co.

Hydrogen Ion Equipment:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Hypochlorite; see Calcium Hypochlorite; Sodium Hypochlorite

Ion Exchange Materials:
Allis-Chalmers Mfg. Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.

Iron, Pig:
Woodward Iron Co.

Iron Removal Plants:
American Well Works
Chain Belt Co.
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Jointing Materials:
Johns-Manville Corp.
Keasbey & Mattison Co.
Leadite Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Permutit Co.
Wallace & Tiernan Inc.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.

Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Foster Eng. Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.
Well Machinery & Supply Co.

Meter Repair Parts:
Meter Specialty Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
F. B. Leopold Co.

Paints:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe, Steel:
Alco Products, Inc.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
Precision Chemical Pump Corp.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Layne & Bowler Pump Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Layne & Bowler Pump Co.
Peerless Pump Div.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sparling Meter Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
Industrial Chemicals, Inc.
International Salt Co., Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Omega Machine Co. (Div., B-I-F Industries, Inc.)
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries, Inc.)
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
W. A. Taylor & Co.
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

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Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

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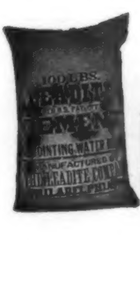

No Caulking